LUNAIRE ENVIRONMENTAL

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VISTA ENVIRONMENTAL

Environmental Test Equipment

Operation & Maintenance Manual

TENNEY ENVIROMENTAL

MODEL NO. TJR

SERIAL NO. 26040-21

Operation and Maintenance Manual

Tenney Junior with Watlow 942

Lunaire Limited

For parts and service, call
717-326-1770

WARNING !

POSSIBILITY OF SEVERE ELECTRICAL SHOCK

Under no circumstance should you attempt any form of maintenance or repair while your Tenney is connected to power.
The machinery compartment contains exposed connexions.
Disconnect all electrical power from the chamber before servicing or cleaning.

WARNING !

THE THJr. IS NOT AN EXPLOSION PROOF CHAMBER !
Do not place anything in the chamber that might release explosive vapours. Do not place pressurized canisters in the chamber.

The Tenney uses refrigerants under high pressure. These refrigerants are harmful to the ozone layer and must be contained. Service of the refrigeration system must only be carried out by a registered, qualified refrigeration mechanic.

OPTIONAL COOLING BOOST: Warning
If your Tenney is equipped with **Nitrogen** or **Carbon Dioxide** boost gas, you should be aware that either gas can cause asphyxiation and even death if used in improperly-ventilated areas. Either gas can cause freeze burning.

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Additional information that should be included with this manual:

Watlow Series 942 User's Manual. This manual contains detailed information on the set-up and use of the 942. Of most interest to you will be the sections that describe programming, tuning, and general operation (CHAPTERS 1, 3, 5, & 6).

Series 942 Quick-Reference Card. This card sums up the basic operational information that you will need to use the 942. Keep it on the front of your Tenney.

Servicing Cascade Refrigeration Systems. This is a technical booklet aimed at the experienced serviceman.

Minco Temperature Sensor Data. This table shows the relationship between temperature and sensor resistance, which uses the European Curve as a basis.

European Curve

100 Ohms at 0°C

$$\frac{\text{Resistance at } 100°C}{\text{Resistance at } 0°C} = 1.3850$$

Preoperation inspection

1. Carefully inspect your Tenney for any damage that may have occurred during shipment. The carrier is typically responsible for the unit once it leaves our dock. If you find damage, contact the carrier. Tenney will do everything possible to assist you in settling a claim.

2. Make sure that each item that is listed on the packing slip is included in the shipment.

3. Inspect the circulation fan inside the chamber. This fan is driven by a motor that is mounted in isolation bushings. Sometime, during shipping, the motor is pushed out of vertical alignment. If this has occurred, the fan blade will strike the casing. Cure the interference by pushing the motor back into alignment on its rubber mounts. However, be sure that the shipping abuse was not so great that the extension shaft on the fan has been bent.

Verify your power source

The Tenney Jr operates on 115 VAC current; however, it has high current demands and should operate on its own branch circuit. Conductors must be 12-gauge AWG or heavier; fusing should be 20 Amp slow-blow or a 20 Amp circuit breaker.

Satisfactory refrigeration performance depends on good line voltage at all times.

Extension cords, even with 12-gauge conductors, are not recommended.

CURRENT DEMAND
Typical measurements using clamp-on ammeter: Chamber at -50°F (-46°C) with refrigeration system at full operation. **14 Amperes** Chamber in heating mode with compressors off and heaters energized. **4.5 Amperes**
FUSING **20 Amp**
VOLTAGE DROP THRESHOLD Measurement at compressor motor terminals (See procedure 004): **104 Volts**

ON and OFF Switch

The ON and OFF switch only controls the circuits described below. It does not disconnect power. The only way to disconnect all power is to disconnect the power cord.

Circuits energized by the On switch

1. fan motor for conditioner
2. pilot light
3. Arms temperature output #1, which arms the heating elements, relay 1CR, and the artificial loading valve.
4. Arms output # 2, which energizes the high-stage compressor, allows the low-stage cut-in switch to start the low-stage compressor, and energizes the coil to relay 1CR (This relay's contacts then reduce heater power from 500 to 250 watts, and simultaneously place the artificial loading valve under command of the controller's output #1. In this configuration, when the controller calls for heat, the controller energizes the 250-watt heater and simultaneously opens the artificial loading valve to reduce refrigeration capacity).

Controller
Watlow 942
made by Watlow Controls
Phone 507-454-5300

The Watlow 942 is a sophisticated device, capable of executing a number of complicated tasks. A great deal of information must be transmitted through a limited display. As a result, many messages in the display are written in a form of alphanumeric shorthand. It is important that you understand the meaning of the symbols. This information is presented in the Watlow manual.

We will give you the basic concepts, but you will need the Watlow manual for the details and more esoteric information.

We suggest that you start with chapter 5.

The intent of this manual is to give you a description of the control's general concept as well as a description of how you go about communicating with the control. Reading this description will help you understand the information in the Watlow manual, where all aspects of the control are described.

DISPLAYS: The upper display typically shows the value and the lower display typically shows the variable or function to which the value applies, i.e., whatever function or variable it is that you are setting (for example: set points, steps, time, etc.).

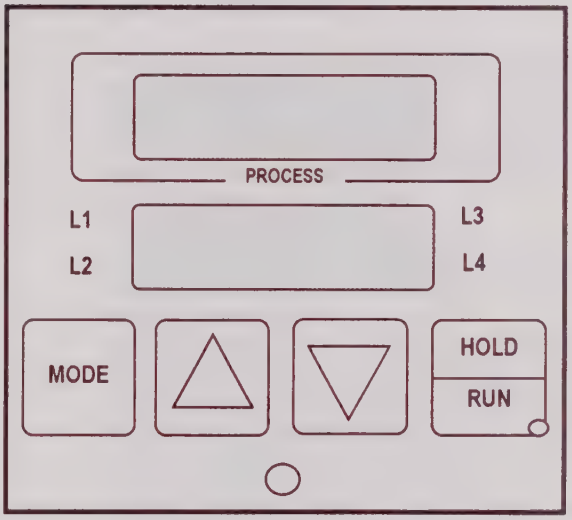
The **MODE** key scrolls you through the menu of variables. It also gives you access in and out of a specific function.

You press the mode key to get into a function; you also use it as an ENTER key once you've obtained the desired value in the display.

The UP and DOWN keys vary the value of the variable in the display. New data are self-entering after 5 seconds.

The **HOLD/RUN** key starts or stops your program. (It can start or stop a program from everywhere but the SET UP menu, which is further described in the Watlow manual.) When pressed once, the **HOLD/RUN** key will take you into a questioning mode, in which the lower display will flash and ask at you which step(**Stp**) you wish to begin. You choose the step with the UP and DOWN keys, and press the **HOLD/RUN** key again to engage the step and run the program.

You program the control in steps. You must set one step at a time, and fully describe that step to the controller. If you make a mistake, you can always scroll through the entire step to get back to whatever function it was that contains the error.



Versions of the 942 controller

Tenney offers the 942 Controller for the TJR in four versions with the following model numbers. The model number is printed on the back of the controller and can be seen when the chamber's control panel is opened.

1. The basic 24-step programmable control, 942-3KD0-AE00.
2. Basic plus two events, 942A-3KD2-AE00.
3. Basic plus communications, 942A-3KD0-BE00.
4. Basic plus events and communications, 942A-3KD2-BE00.

Note: The communications arrangement is isolated RS-423/RS422. Each event output is made through a mechanical relay having contacts rated for 6 Amps at 120 or 240 VAC.

Typical programming operation for one step. You can program up to 24 steps, but you may not always need that many.

Press MODE key.
ProG will appear in the lower window, questioning whether you want to program.
Press the UP or DOWN key to choose **YES** or **nO**.
Press MODE key. This will enter the **YES** and move you to the next programming task:
StEP appears in the lower window,questioning which step you wish to start with. (Since it's unlikely that your control will have any programs in residence, Step 1 would be a logical starting place). So use the UP and DOWN keys to select **1**. Enter 1 by pressing the MODE key.

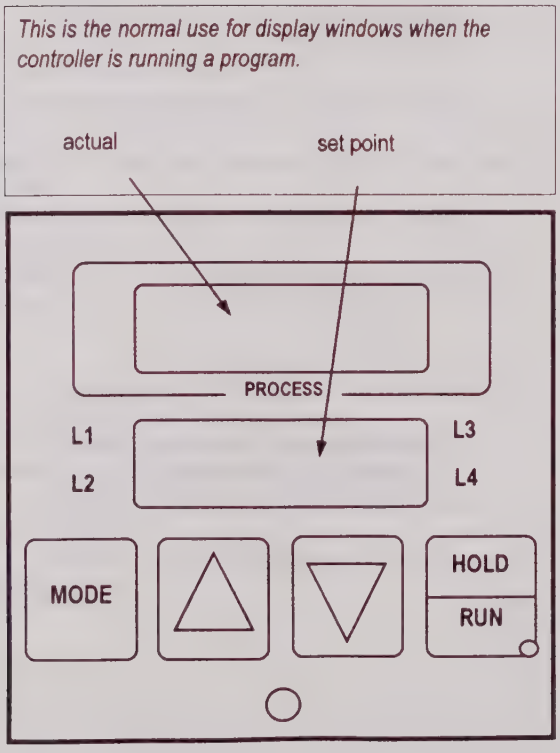
The alphanumeric shorthand for steps is are as follows.

Set point:	StPe
Soak:	SoAh
End:	End
Jump loop:	JL

Note that Jump loop will not appear the first time that you program because, at that point, there is not pre-set step in the program to which you can jump. JL will apear in the Step menu after you have entered your first step.

StYP will appear in the lower window, questioning what kind of step you wish to perform. You can choose from four different step types(set point, soak, jump loop, or end) by using the up and down keys. We shall assume that you are planning to set a desired temperature. Thus use the UP and DOWN keys until **StPt** appears in the upper window.
Enter by pressing the MODE key.
SP will appear in the lower window. Use the up and down keys to reach the desired temperature, and press MODE to set, or enter, the temperature.
HOUr will appear in the lower window. The next three functions are for setting the amount of time over which you intend to reach the first temperature set point. You will enter the hours, minutes (**Min**),and seconds (**SEC**) separately,using the UP and DOWN keys. Remember to enter each time quantity and move on to the next by using the MODE key.
rtn will appear in the lower window, questioning whether you want to program additional steps (in which case , believe it or not, you select **no**). Or, by selecting **YES**, you exit the program menu and *return* to control set point. In our example, we choose **YES.**

This is the normal use for display windows when the controller is running a program.



To run your 1 step program, press the HOLD/RUN key. The displays and the hold/run pilot light will start flashing, the lower window will display **StEP,** and the upper window will display the first step of the program that is ready to run. In this case, we only have 1 step. To start the program, press the HOLD/ RUN key again.
You will need an **End** step to end the program.

The TJR is shipped from Tenney with HYS set at 4 and db set at -3, as shown on the top line in the chart. **It is unlikely that you will want to change these settings.** In fact, you may wish to skip this page entirely, and come back to it if and when the need arises.

Fortunately, these settings are not subject to "cold start" default, and will remain valid after a power interruption. They are held in EEROM, not battery-backed RAM.

In the unlikely event that you get a 942 controller directly from Watlow, it will probably have settings of HYS 3 and db 0. This will cause the compressor to cycle on and off every 3 degrees, which will put undue strain on the refrigeration system. Should you purchase a control in such a manner, you will have to readjust, or set , the controller to Tenney's standard settings.

EXAMPLE SETTINGS FOR HYS and DB

These settings are made through the Watlow control.

	HYS	db	Turn-on (above SP)	Turn-off (below SP)
Standard	**4.**	**-3.**	**1.**	**3.**
	5.	-3.	2.	3.
	5.	-1.	4.	1.
No Good	3.	0	3.	0

Compressor turn-on logic

The 942 Controller on the TJR is a single-channel instrument. Temperature setpoints are entered into channel #1 in °C or °F as described in the Watlow User's Manual, q.v., Output #1 controls heating and cooling.
Output #2 is set up to turn refrigeration on and off in response to cooling demands.

Internal signals furnish logic to output #2, telling it when to energize the refrigeration system and when to shut it down. The signals are as follows.

1. **Actual chamber temperature**: the measured variable sensed by the chamber's temperature sensor
2. **Setpoint** temperature: the temperature you have keyed into channel #1.
3. **Hysteresis**: the temperature change necessary to change the output from on to off.
4. **Deadband**: the temperature band between the heating and cooling functions.

You will enter both HYS and db in °C. Deadband is always a negative and the logic is as follows.

* Measured temperature rises above setpoint: Refrigeration *turn-on* equals hysteresis minus deadband.
* Measured temperature falls below setpoint; turn-on is always above setpoint.
* Turn-off is always below setpoint; turn-on is always above setpoint.

Preventive maintenance

In addition to ordinary cleaning, oiling hinges, and general housekeeping maintenance, we suggest a few simple, periodic preventive maintenance measures.

The refrigeration compressors are hermetically sealed, internally sprung, and are not user serviceable. However, examine them occasionally, making sure they are well secured and that vibration has not chafed pressure or suction lines.

Be sure each starting capacitor, relay, and thermal overload are firmly clipped in place on the hermetic unit.

Once or twice a year, clean the condenser coil with a vacuum cleaner and brush. Frequency of cleaning depends upon the dustiness of your location. To get at the coil, remove the right panel.

As required, clean the inside of the chamber. Carefully clean the blades of the conditioner fan.

Inspect the door seals, making sure the door closes tightly. Even the smallest leak can degrade thermal performance.

Make sure the chamber has not been pushed into a tight corner where its refrigeration system cannot breathe. Also, see that it is not operating on an extension cord, and finally, make sure the chamber is well grounded.

Electrical

Item	Measurement	Resistance
Compressor start	common term	5.7 Ohms
Compressor run	common term	.7 Ohms
Compressor shell	common term	Infinite
Conditioner	across terminals	20 Ohms
Heater element	HL to 3	55 Ohms
Heater element	HL to 4	55 Ohms
Solenoid valve	across coil	80 Ohms
Temperature	across terminals	100 Ohms
Condenser fan	across terminals	37 Ohms

A good ohmmeter is a great help in trouble shooting the electrical and control system. The use of an ohmmeter and reference to the schematic drawing included with this manual should help you locate difficulties.

The Chart is a tabulation of more important "normal" resistances measured on new equipment at room temperature. Remember, though, that resistances vary considerably from item to item and ohmmeters deviate from one instrument to another. Use the table of values as a guide, realizing that moderate variations do not necessarily indicate trouble.

Satisfactory refrigeration performance depends on good line voltage at all times. Incoming power lines should be heavy enough that voltage never drops below 104 volts measured close to the compressor motor terminals. If the compressors seem to struggle when starting, measure this important voltage.

Note: Terminal arrangement on the Copeland compressor units is as follows: There are 3 terminals. Center top one (12 o'clock position) is common. Going clockwise to the 4 o'clock position is the run winding terminal. Around the 8 o'clock position is the start winding terminal. All are insulated from ground. See photos under specific tasks .

Trouble shooting

Be careful! The Tenney Junior has wires carrying 115 volts with heavy current carrying capacity. Unplug the unit from the electrical power supply before making trouble-shooting tests. The ON/OFF switch, when opened, disables the conditioning equipment but does not remove voltage from across the main line. This circuit remains hot.

A list of possible malfunctions, their symptoms, principal causes and remedies are found in the trouble shooting chart which follows.

Components of the refrigeration system are included in the trouble chart to assist you in pinpointing malfunctions. But do not attempt to repair sealed portions of the refrigeration system: **This should be done by Tenney only**. However, the Hermeticool refrigeration system is highly reliable and is seldom the cause of trouble. Controls, fans, wiring, and capacitors are more likely to give trouble than sealed compressors.

Current demand

Typical current draw measured with a snap-on type probe ammeter on the power cord with the chamber at -50°F (-46°C) and the refrigeration system operating fully, is about 14 Amperes. Typical current with heaters only and the heaters energized (compressors off) is about 4.5 Amperes.

Replacement parts

There are no special procedures to replace any of the unit's components. All parts are accessible after panels are removed. Note that while the hermetically sealed refrigeration system must not be opened, the coil in the artifical loading solenoid valve may be replaced without disturbing the soldered tubing.

When ordering parts or writing about your Tenney Jr., please state the serial number of your unit. It is stamped on the rating plate to the rear of the cabinet.

When writing about the refrigeration system, please supply the chamber's serial number.

Parts identification

Component parts are shown and identified on the drawings accompanying this manual. The bills of material indicate name and number of the part to be used in ordering parts.

Parts requisitioning

Parts can be ordered directly from Tenney, 4 Quality Street, Williamsport, PA, 17701. Phone: 717-326-1770. Fax: 717-326-7304.

Under no circumstance should you attempt any form of maintenance or repair while your Tenney is connected to power. The machinery compartment contains exposed connexions. Disconnect all electrical power from the chamber before servicing or cleaning.

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION	TASK NUMBER
Compressor will not start and there is no hum	line disconnect (breaker) switch is open	reset	
	broken wire	inspect and repair	
	overload protector has tripped	wait 5 minutes. If overload does not close, replace it.	001
Compressor hums but will not start	low supply voltage	get proper electrical service	
	starting capacitor is defective	replace with one of same specification	002
	relay is failing to operate	inspect, replace	003
	compressor has internal problems	measure winding resistances, test for grounds. Call Tenney.	004
Compressor starts, hums, runs slowly, staying on the start winding	low line voltage	get proper electrical service	
	relay is stuck	replace	003
	shorted winding	test resistances,test for grounds. Notify Tenney	004
Compressor runs but cools inefficiently	restricted ventilation, dirty condenser fins	Move unit away from wall. Clean condenser fins	006
Refrigeration works long or continuously	Excessive heat load	reduce load if possible	
	ice on evaporator coil	defrost	007
	low refrigerant charge	Have charge checked by refrigeration mechanic. Charges are on identification label.	
Compressor repeatedly trips out overload protector	Pressure switch failure	Have refrigeration mechanic check switches. Call Tenney.	005
Insufficient heat	heat limited failure	Check limiter	007
	control failure	carefully check programming as well as control relay	

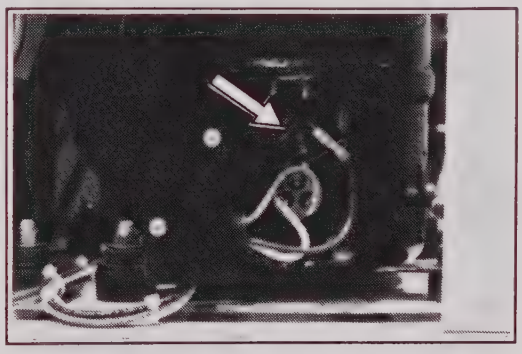
PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION	TASK NUMBER
Excessive heat	Control failure, or triac is locked "on"	Check triac. Check Watlow manual	
Repeated shorting or blowing of start capacitors	Excesive start time , voltage too low.	Correct low voltage trouble	
	improper relay installed by others		008
	improper capacitor installed by others	consult with Tenney, and obtain correct capacitor	002
Unit runs well but there is a minimum chilling of the evaporator coils	Solenoid valve (artificial loading) stuck in open position.	Check with Tenney regarding replacement.	008
Noisy compressors	Compressor loose on mounts.	tighten hold downs	009
Noisy compressors, even with secure hold-downs	Broken springs within compressor housing	Replace compressor. Call Tenney for assistance.	

Task procedures

Replacement of overload protector 001

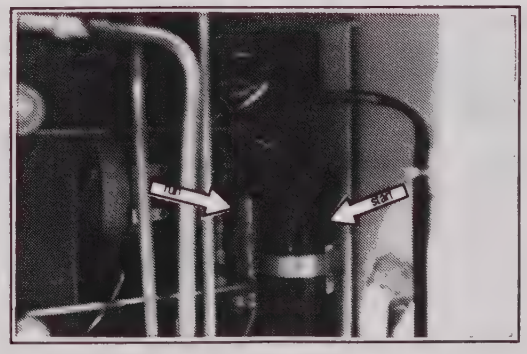
Unplug chamber from power outlet.

Remove right side panel.
The overload protector is identified as shown in the photo. It is held in place by a spring clip and a wire connection. You will also need to remove the compressor relay cover.

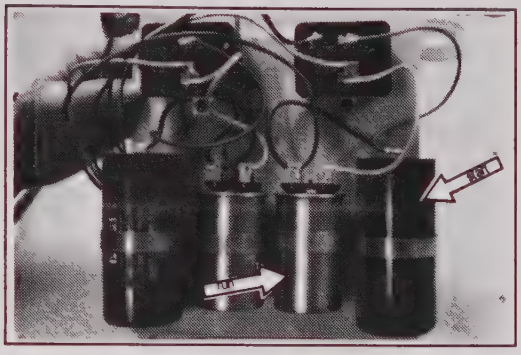


Replacement of starting capacitor and running capacitor 002

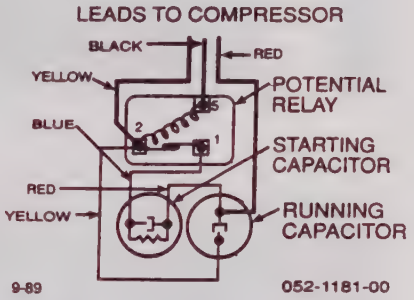
Unplug chamber from power outlet.
A capacitor, if associated with a malfunctioning bleeder resistor, can store electrical energy. Be cautious!
Remove right side panel.
Each capacitor is identified as shown in the photo. The capacitor is held in place by a screw, positioned between two clamps.



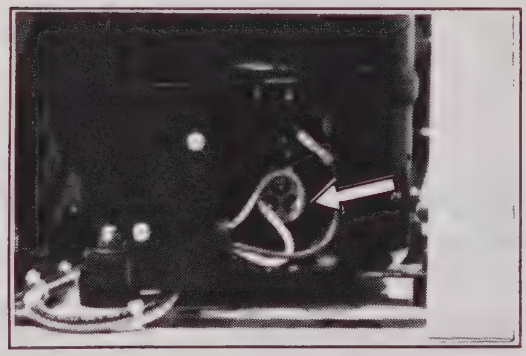
003 Replacement of compressor relay

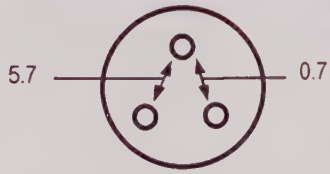


Unplug unit from power outlet and remove side panel. Disconnect and mark wires. *Note wiring description that is printed in relief on the inside of the relay cover, shown below.* Replace with a new relay, making sure to mount the new relay in the same position as the old relay. Relay is marked "this side down".



004 Measurement of winding resistances





Unplug from power outlet.
Remove right hand side panel.
Locate relay. *The compressor wiring is always decribed in a diagram that is printed on the inside of the relay cover.* The terminal cover is easily removed by releasing the spring clip that holds it in place. Once the cover has been removed, you shall see the compressor relay as shown. Pull the wires away from the pins connections to which it is affixed. The pins shall be arranged as depicted in the drawing. Use an Ohm meter.
Note: see page 9 for other resistance checks.

Item	Measure	Resistance
Compressor Start	common	5.7 Ohms
Compressor Run	common	0.7 Ohms
Compressor Shell	common	Infinite

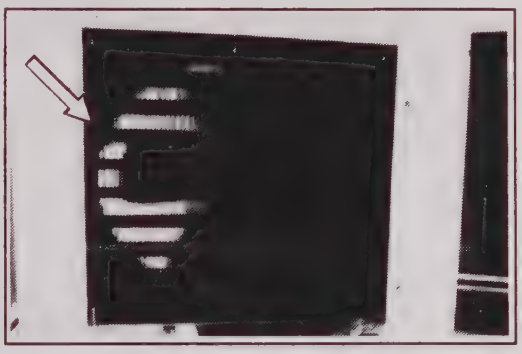
005 Location of pressure switches

The Tenney Jr is equipped with two pressure switches, located just above each of the compressors, as shown. The low stage switch is set for 20 psi, and the other switch, which by-passes the second stage when high chamber temperatures might induce excessive head pressure, is set to dump at 280 psi.

Examination of the switches can only be carried out by a refrigeration mechanic. If you suspect a problem, call Tenney.

Cleaning condenser coils 006

The condenser coils are easily accessed from the right-hand side of the chamber. A powerful vacuum cleaner may be used to draw lint and dust from the between the fins. Care must be exercised because if the fins bent, the flow of cooling air will be impinged.
For a thorough cleaning, the rear panel may be removed, allowing access to the inside of the coil.

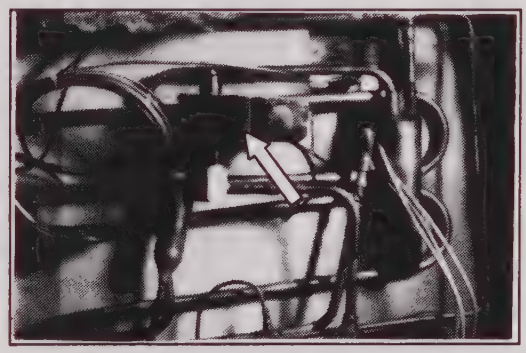


Evaporator coil location 007

You may need to access the evaporator coil in cases of excessive frost build-up.
The evaporator coil can be accessed by removing several screws in the top of the work chamber that holds the plenum housing in place. Once this has been done, the coil is easy to examine.
Also visible in this photo are the heater racks, the circulation fan, the RTD probe, and the auxiliary RTD port.
The heat limiter is located at the back of the heater rack, which is visible just to the left of the coil.

Solenoid valve 008

The solenoid valver is easily accessed by removing the rearmost cover panel of the Tenney. The valve can be examined without disruption of the refrigeration change.
If the capillary tube is frosting while the control is calling for temperature pull-down, it is very likely that the valve is stuck in the open position. Light taps with a non-destructive tool, such as a rubber hammer, will sometimes free the valve. If the problem persists, call Tenney.



Compressor hold downs 009

The compressor hold downs are shown in the photo. Any looseness will be obvious. If noise continues even after the hold-downs have been checked, it is likely that one of the springs in the compressor is broken. You should have the compressor checked by a refrigeration mechanic and get a new one on order.

Dimensions in inches/centimeters

Model		TJR	TUJR	THJR
Workspace	W	15⅝ / 40		16½ / 42
	D	11 / 28		15¾ / 40
	H	11¾ / 30		20 / 51
Exterior	W	36¾ / 93	28 / 71	51/ /130
	D	22½ / 57	20 / 51	24 / 61
	H	30½ / 78	65 / 165	30 / 76

Temperature Range

Low	°C	-80	-12
High	°C	+200	+93

Change rates in minutes

Ambient to °C	200°	55	–
Chamber Empty	150°	30	–
	100°	15	–
	93°	–	30
	65°	–	15
	2°	–	20
	-7°	–	30
	-12°	–	45
	-40°	20	–
	-54°	30	–
	-65°	40	–
	-73°	55	–
	-80°	Ultimate	–

Live load capacity in watts (humidity system off)

Temperature	24°	–	275
°C	10°	–	170
	-7°	–	45
	-12°	–	5
	-40°	170	–
	-54°	145	–
	-65°	105	–
	-73°	60	–
	-80°		–

Utilities, etc.

Refrigeration		(2) ½ HP + ⅓ HP		(1) ⅕ HP
Heater Capacity		500W		500 W
Humidifier	W	–	–	500
	GPH	–	–	0.15
AMPS @ 115V, 1Ø		18		12
AMPS, Fuse		20		15
Unit Weight	LBS / KG	260 / 118		275 / 125

Humidity capability: 20% to 98% RH in the dry bulb range of +20°C to +85°C as limited by a 3° dewpoint.

Test data based on 24°C ambient, sea level, 60Hz. On 50 Hz or higher than 24°C ambient, performance may be reduced. Consult factory regarding any special cooling requirements.

CFC-free refrigerants are used exclusively on all Tenney chambers.

TENNEY ENVIRONMENTAL

SERVICING CASCADE REFRIGERATION SYSTEMS

Tenney Environmental
1719 Route 10 East
Suite 301
Parsippany, NJ 07054

SERVICING CASCADE REFRIGERATION SYSTEMS

INTRODUCTION

This information is written to help the refrigeration serviceman repair and trouble-shoot low temperature cascade systems. It is assumed that the reader is familiar with standard refrigeration practice and is interested in the special techniques applicable to cascade systems.

HISTORY

Prior to the development of low boiling point refrigerants such as R13 (-114 deg. F) and R503 (-127 deg. F), reaching ultra low temperatures with mechanical refrigeration was difficult. R22 was used down to -80 deg. F, but its system had serious drawbacks. Large and cumbersome, the machinery was subject to the many troubles that afflict a compound system operating at suctions as low as 23 inches of vacuum. The modern cascade system can reach as low as -120 deg. F with suction pressures of 0 PSIG or higher. Compact, serviceable, and reliable, today's cascade system is found on thousands of environmental test chambers.

HOW IT WORKS

Two types of popular cascade systems are expansion valve and capillary tube. Both are discussed in the text, and capillary systems are shown in the schematics that comprise part of this manual.

Refrigerants with low boiling points have correspondingly high condensing pressures at normal ambients. They cannot be liquefied by conventional air or water-cooled condensing units. Therefore, low temperature refrigerants are condensed by a separate refrigeration system called "the high stage". The sole job of the high stage in most cascade systems is to condense low stage refrigerant.

HIGH STAGE

The high stage is a conventional single-stage system having a compressor, air or water cooled condenser, expansion valve, and evaporator. The evaporator is the cascade condenser, serving the low stage. Modern systems use R404a in the high stage, making -50 deg. F refrigerant temperature possible at 0 PSIG suction pressure.

LOW STAGE

The low stage is charged with refrigerant in vapor phase only, to a specified gauge pressure. When the low-stage is idle with all components stabilized at 70 deg. F, it will contain no liquid refrigerant. When the system is activated, the low stage compressor will pump hot gas through the discharge line to the de-superheater. The de-super-heater, air or water-cooled, removes some heat from the refrigerant gas, lightening the heat load on the cascade condenser. Leaving the de-superheater, the gas passes through an oil separator, then flows to the cascade condenser where it is liquefied by heat exchange with high stage refrigerant and flows to the expansion valve.

EXPANSION VALVE

The expansion valve meters refrigerant to the cooling coil located in the workspace. In the coil, refrigerant evaporates, absorbs heat, then returns to the compressor as a cold gas.

FROSTED LINES ARE TYPICAL

A low-stage characteristic is frosted liquid and suction lines. In a normal cascade system, the liquid line is always below +32 deg. F. The suction line, returning from a -100 deg. F evaporator, assuming 15 degree superheat, will also be far below freezing.

EXPANSION TANK

An expansion tank is provided to add volume to the low stage. Added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is sucked out of the expansion tank during system operation: It is metered through a constant pressure valve, capillary tube, or needle valve, the valve or restriction regulating the rate of gas entry into the system.

LOAD LIMIT VALVE

Connected between expansion tank and discharge side of the low stage, a load limit valve acts as a relief device. It bleeds down or dumps gas into the expansion tank when low stage discharge pressure reaches valve setting, usually 185 to 240 PSIG. High pressures are generated when the low stage starts up but the load limit valve, acting as a relief, prevents the compressor from cycling on and off in response to signals from the high pressure cutout.

LEAK TESTING

Loss of refrigerant is the most common cause of refrigeration failure. Because of temperature extremes experienced by its metal parts, the cascade system is particularly susceptible to leaks.

Check the entire system with an electronic leak detector. If the system is empty or at low pressure, boost pressure to 200 PSIG with inert gas (not oxygen) diluted with a percentage of high stage refrigerant. Test again.

A leak check while the system is at low temperature, -80 deg. F or colder, is a necessity. Expansion valve flanges, superheat adjustment caps, and other mechanical joints should be tightened and checked for leaks while at low temperature.

You may use a Halide torch to locate large leaks, but make your final test with the more sensitive electronic leak detector. This is especially important on the low stage. The low stage is gas charged with a relatively small quantity of refrigerant. Because of this, small leaks can quickly incapacitate the system.

TESTING BY STATIC CHARGE

One advantage of a gas charged system is that its tightness can be checked by periodic observation of static or standby pressure. You must read the pressure with all parts of the system at ambient temperature. This is important. The unit must be shut down at least 24 hours before a static pressure reading is taken. To eliminate the possibility of cooling the cascade condenser with the high-stage, pump-down cycle, all power to the unit must be off during the shut down period.

When reading static pressure, consider ambient temperature. Most static charge data are for a 10 deg. F decrease in temperature. Due to a large system's considerable thermal mass, several days may be required for all components to completely stabilize at a particular ambient.

EVACUATION

Granted, refrigerants R23 and R404a are expensive, but there are times when charges must be recovered. A contaminated system must be cleaned and evacuated regardless of refrigerant expense.

If there is a possibility that moisture, non-condensibles, or the wrong refrigerant contaminated a system, recover the charge and evacuate.

Select a two-stage pump capable of pumping the system down below 200 microns, and connect an appropriate gauge to ready system pressure. The ordinary compound refrigeration gauge is inadequate, however a thermocouple gauge is ideal. Evacuating a leaky system is an exercise in futility; therefore, make sure the system is absolutely tight before beginning evacuation.

CHARGING A LOW STAGE

1. Do not charge liquid into the low stage.
2. Do not charge the system when it is below room temperature.
3. Do not use charging hoses on very high pressure refrigerants or low stage refrigerants. Cylinder pressure exceeds 500 PSIG.
4. Never charge the unit when it is running.

As you will note from the above, low stage charging procedure differs from the conventional method. Correct charging pressure will be noted on the equipment nameplate or in the instructions. Remember, it is important that you charge by pressure, not by volume of refrigerant.

Use 1/4 inch copper tube between refrigerant cylinder and system. Open the cylinder valve very slowly. Charge into the suction side while closely watching the discharge gauge. When correct pressure is reached, shut off the refrigerant cylinder valve, allowing the system to equalize from 10 to 15 minutes. If the pressure drops, crack open the cylinder valve, and slowly raise the pressure. Always take enough time: systems with expansion tanks connected by a capillary tube or restrictor valve may need several minutes for gas pressure to equalize.

Keep the refrigerant cylinder upright when charging. Above all, be careful. Do not over-pressurize. Disconnect the cylinder immediately when charging is complete. A leaky cylinder valve could continue to bleed high pressure refrigerant into the system, possibly causing it to rupture. Do not take chances. The saturation pressures of low temperature refrigerants are extremely high.

DRAWING NO. 1

A small cascade system, using two ½ HP hermetic compressors is delineated in this schematic. The high stage charge is noted on the serial tag. The low stage carries a static pressure, noted on the serial tag, at room temperature. 10 cc of pentane is added to the low stage charge to help prevent waxing of the lubricant at extremely low temperatures.

Flow of refrigerant in the high stage is from compressor C2 in the form of a hot gas, to the chamber door mullion heater(optional), and then to the air-cooled condenser. As a liquid, the high stage refrigerant flows from the condenser to capillary tube driver assembly D2, which meters refrigerant to the cascade condenser. After evaporating in the condenser assembly, which is a heat-exchanger, the high stage refrigerant returns to the compressor C2 through the suction line and accumulator SLA.

The function of pressure switch PS3 is to energize the low stage compressor after the high stage has started. The purpose of the arrangement is to prevent both compressors from hitting the power line at the same instant.

Refrigerant flow in the low stage is from the compressor through the de-superheater to the cascade condenser where gaseous very high pressure refrigerant or low stage refrigerant is cooled and liquefied. Capillary tube assembly D1 meters very high pressure refrigerant or low stage refrigerant into the evaporator which cools the chamber. From the evaporator, refrigerant returns to the compressor through the suction line.

Excess refrigerant is stored in the expansion tank and is fed back to the system on demand through a capillary tube.

Solenoid valve SV serves two purposes: On a cooling "off" cycle, it functions as an artificial loading valve, partially by-passing the evaporator and reducing cooling capacity. Refrigeration is modulated through this valve, not by cycling of the compressors. Valve SV also functions as a dump valve. Responding to signals from pressures with PS1, it opens when head pressure exceeds a predetermined pressure setpoint, typically 280 PSIG.

DRAWING NO. 2

When operated in cascade mode, the system shown on this schematic functions essentially the same as the two systems previously described. High stage refrigerant flow is from compressor C2, through the mullion heater to the condenser, then through cap tube assembly S to the cascade condenser. Return flow is through the suction line and accumulator SLA. Flow of low stage refrigerant is from compressor through cascade condenser and cap tube S to the low temperature coil, then back to the compressor through the suction line. Valve SV14 functions as modulating (artificial loading) and dump valve in the usual manner.

Low stage compressor C1 is shut down when the system operates in single-stage mode for "ambient" cooling and workspace de-humidification. High stage flow is then as follows:

After being liquefied in the condenser, refrigerant flows to solenoid valves SV1 and SV4. When the dry bulb temperature controller calls for cooling, it opens valve SV1, admitting refrigerant to the ambient cooling coil. After evaporating, the high stage refrigerant, as a cool gas, returns to the compressor through the evaporator pressure regulator AEV and the suction line. The purpose of the regulator AEV is to prevent the ambient coil from operating too cold, a condition that is undesirable when the chamber is being operated at high humidity.

When the humidity control signals for decreased workspace humidity, control voltage is applied to solenoid valve SV4. Refrigerant is admitted to the de-humidification coil, returning to the high-stage compressor through the suction line.

Capillary tube S, which feeds the cascade condenser, is not valved off while the high stage operates in "ambient" single stage configuration. It functions as a by-pass so that when solenoid valves SV1 and SV4 are both closed, there remains a path through which refrigerant can circulate. On most larger systems, this line is valved off, and other forms of by-pass are provided.

CASCADE REFRIGERATION GLOSSARY

Cascade Condenser: The high stage system's evaporator and low stage system's condenser. It can be either tube-in-tube with the low-stage refrigerant in the outside tube or tube-in-shell with the low-stage refrigerant in the shell.

De-superheater: Can be either air or water-cooled. Its purpose is to remove some heat from the low stage discharge gas and thereby lighten the load on the high-stage condenser that is used as the de-superheater. Water-cooled de-superheaters are either tube-in-tube or shell-in-tube. The water flow is usually in series with the high-stage condenser.

Low stage: The low temperature stage or system that cools the chamber or workspace evaporator. Low stage refrigerants have low boiling points and correspondingly low condensing temperatures.

High Stage: Used to cool the low stage condenser. Some high stage systems are used, as a separated function, to provide moderate cooling for the chamber workspace.

Load Limit Valve: Sometimes called dump or blow down valve. Located between the discharge side of the low stage and the expansion tank, this valve opens, allowing gas to flow into the tank, thereby reducing head pressure.

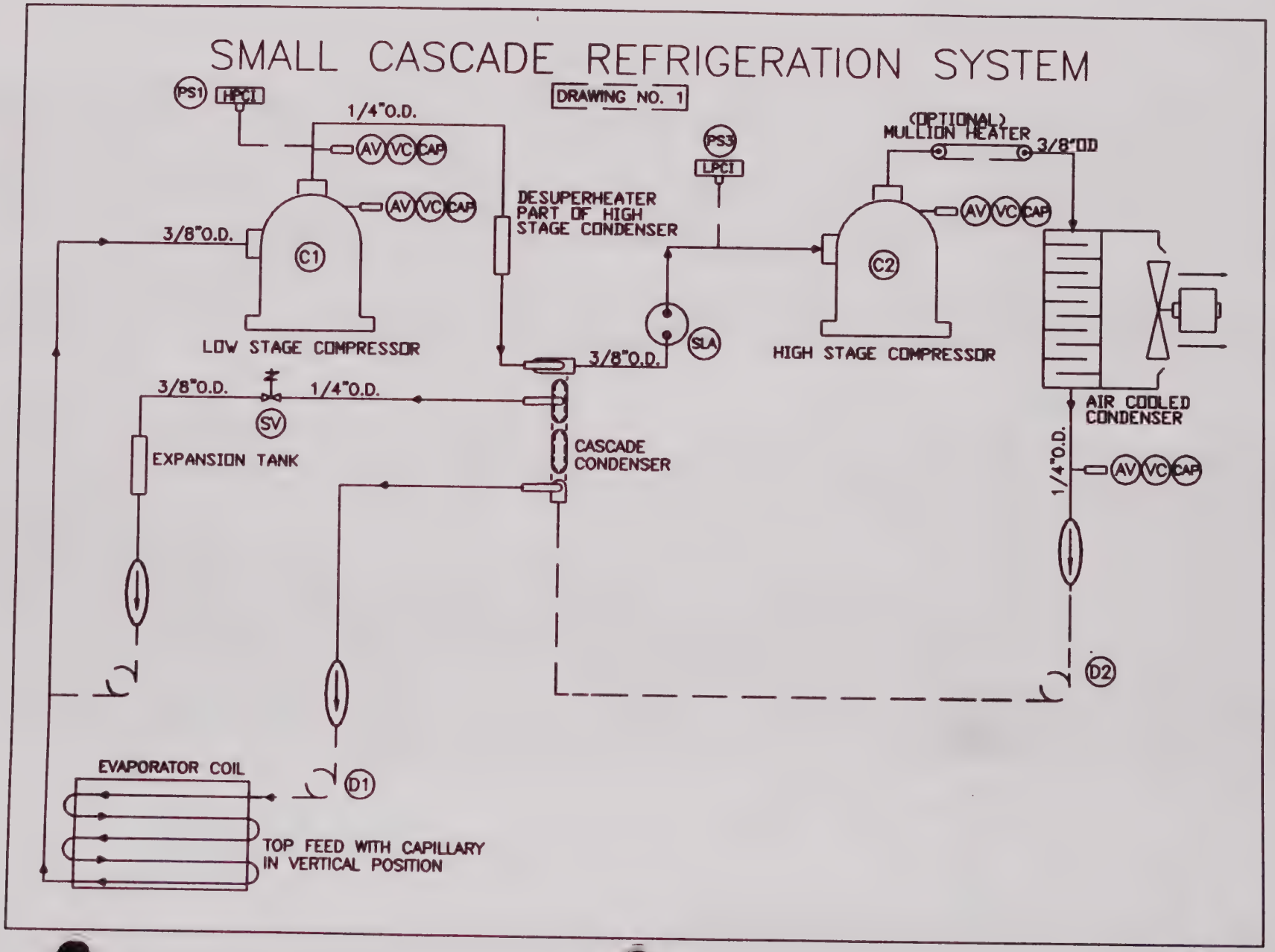
Expansion Tank: Used in the low-stage to provide additional system volume. It allows the use of sufficient refrigerant charge, while maintaining reasonable standby or static pressure.

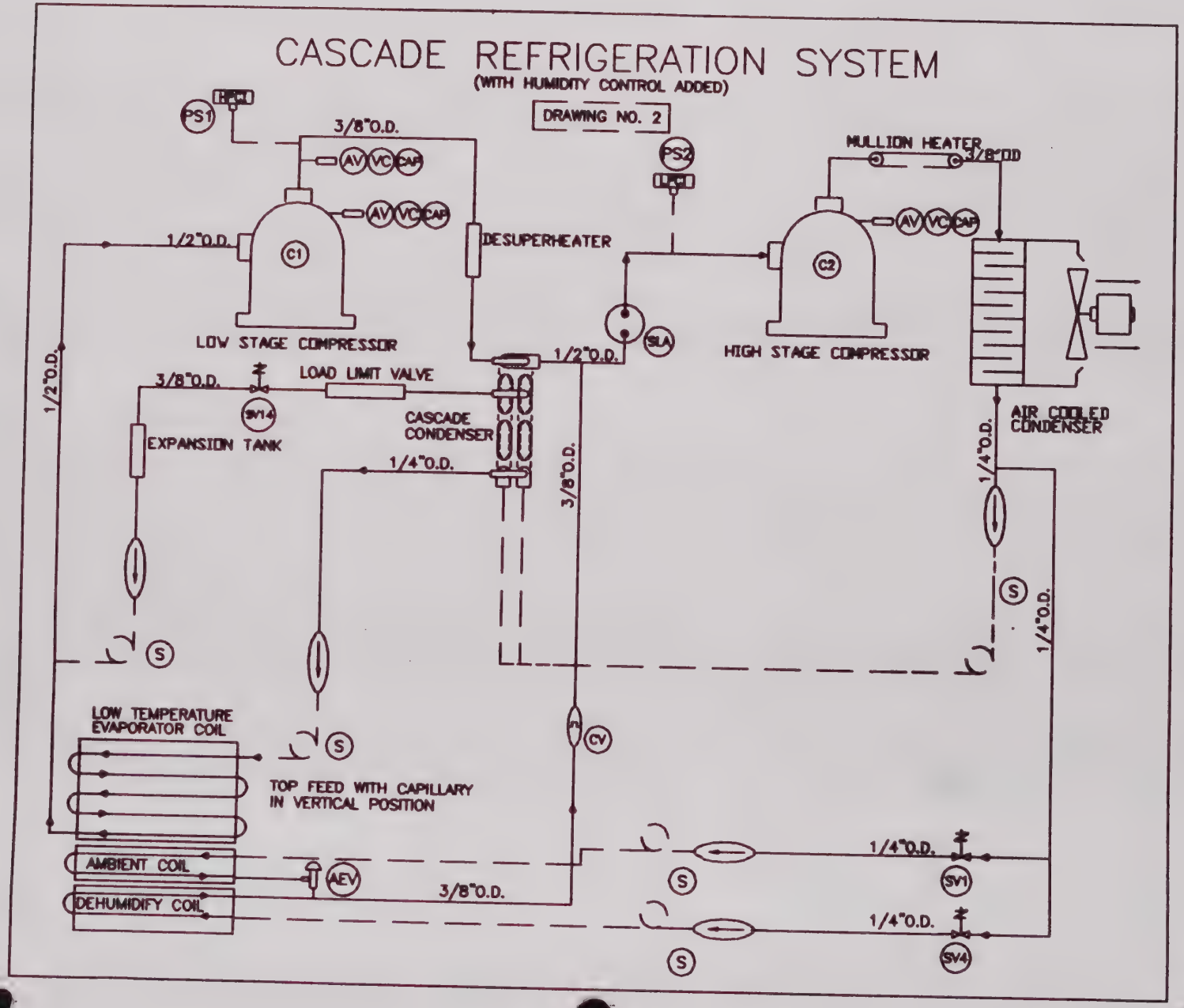
Static Charge: The gauge pressure indicated in the low stage. The equipment manufacturer will designate proper static or standby pressure for a particular unit. A typical nameplate will specify low stage R23, 7 lbs. static 120 PSIG. This means that if you add R23 gas to an evacuated unit, until system pressure is 120 PSIG, you will have removed 7 lbs. from your cylinder.

Pull Down Time: The length of time required to lower air in the chamber workspace from ambient, a nominal 70 deg. F, to the desired low temperature. The temperature is measured at the discharge of the fan. Air is normally drawn over the evaporator and discharged into the workspace.

Sub Zero Cooling: The term used to describe the mode of cooling wherein the low-stage refrigerant is used to cool the workspace.

Ambient Cooling: Describes the high stage unit being used to cool the workspace with its own evaporator.


SMALL CASCADE REFRIGERATION SYSTEM
DRAWING NO. 1
PS1
HPCI
1/4"O.D.
AV
VC
CAP
PS3
LPCI
(OPTIONAL)
MULLION HEATER
3/8"OD
DESUPERHEATER
PART OF HIGH
STAGE CONDENSER
3/8"O.D.
C1
C2
LOW STAGE COMPRESSOR
SLA
HIGH STAGE COMPRESSOR
3/8"O.D.
1/4"O.D.
SV
AIR COOLED
CONDENSER
EXPANSION TANK
CASCADE
CONDENSER
1/4"O.D.
D2
EVAPORATOR COIL
D1
TOP FEED WITH CAPILLARY
IN VERTICAL POSITION


CASCADE REFRIGERATION SYSTEM
(WITH HUMIDITY CONTROL ADDED)
DRAWING NO. 2
PS1
PS2
3/8"O.D.
AV
VC
CAP
C1
C2
1/2"O.D.
DESUPERHEATER
MULLION HEATER
LOW STAGE COMPRESSOR
HIGH STAGE COMPRESSOR
SLA
LOAD LIMIT VALVE
SV14
EXPANSION TANK
CASCADE CONDENSER
AIR COOLED CONDENSER
1/4"O.D.
S
LOW TEMPERATURE EVAPORATOR COIL
TOP FEED WITH CAPILLARY IN VERTICAL POSITION
CV
AMBIENT COIL
DEHUMIDIFY COIL
AEV
SV1
SV4

MINCO

RESISTANCE TEMPERATURE TABLE
U.S. INDUSTRIAL SPEC. $R_{100C}/R_{0C} = 1.3911$
PLATINUM RESISTANCE THERMOMETER
100 OHMS AT 0°C.

TABLE 11-100

7300 Commerce Lane | Minneapolis, Minnesota 55432 | TWX: 910-576-2848 | Telephone : (612) 786-3121

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
-200.0	17.26	-155.0	36.67	-110.0	55.51	-65.0	73.93
-199.0	17.70	-154.0	37.09	-109.0	55.93	-64.0	74.34
-198.0	18.14	-153.0	37.52	-108.0	56.34	-63.0	74.74
-197.0	18.58	-152.0	37.94	-107.0	56.75	-62.0	75.15
-196.0	19.01	-151.0	38.37	-106.0	57.17	-61.0	75.55
-195.0	19.45	-150.0	38.79	-105.0	57.58	-60.0	75.96
-194.0	19.89	-149.0	39.21	-104.0	57.99	-59.0	76.36
-193.0	20.32	-148.0	39.63	-103.0	58.40	-58.0	76.77
-192.0	20.76	-147.0	40.06	-102.0	58.81	-57.0	77.17
-191.0	21.20	-146.0	40.48	-101.0	59.23	-56.0	77.58
-190.0	21.63	-145.0	40.90	-100.0	59.64	-55.0	77.98
-189.0	22.07	-144.0	41.32	-99.0	60.05	-54.0	78.39
-188.0	22.50	-143.0	41.74	-98.0	60.46	-53.0	78.79
-187.0	22.94	-142.0	42.16	-97.0	60.87	-52.0	79.19
-186.0	23.37	-141.0	42.59	-96.0	61.28	-51.0	79.60
-185.0	23.80	-140.0	43.01	-95.0	61.69	-50.0	80.00
-184.0	24.24	-139.0	43.43	-94.0	62.10	-49.0	80.40
-183.0	24.67	-138.0	43.85	-93.0	62.51	-48.0	80.81
-182.0	25.10	-137.0	44.27	-92.0	62.92	-47.0	81.21
-181.0	25.54	-136.0	44.69	-91.0	63.33	-46.0	81.61
-180.0	25.97	-135.0	45.10	-90.0	63.74	-45.0	82.01
-179.0	26.40	-134.0	45.52	-89.0	64.15	-44.0	82.42
-178.0	26.83	-133.0	45.94	-88.0	64.56	-43.0	82.82
-177.0	27.26	-132.0	46.36	-87.0	64.97	-42.0	83.22
-176.0	27.69	-131.0	46.78	-86.0	65.38	-41.0	83.62
-175.0	28.12	-130.0	47.20	-85.0	65.79	-40.0	84.03
-174.0	28.55	-129.0	47.62	-84.0	66.20	-39.0	84.43
-173.0	28.98	-128.0	48.03	-83.0	66.61	-38.0	84.83
-172.0	29.41	-127.0	48.45	-82.0	67.02	-37.0	85.23
-171.0	29.84	-126.0	48.87	-81.0	67.42	-36.0	85.63
-170.0	30.27	-125.0	49.28	-80.0	67.83	-35.0	86.03
-169.0	30.70	-124.0	49.70	-79.0	68.24	-34.0	86.43
-168.0	31.13	-123.0	50.12	-78.0	68.65	-33.0	86.84
-167.0	31.56	-122.0	50.53	-77.0	69.06	-32.0	87.24
-166.0	31.98	-121.0	50.95	-76.0	69.46	-31.0	87.64
-165.0	32.41	-120.0	51.37	-75.0	69.87	-30.0	88.04
-164.0	32.84	-119.0	51.78	-74.0	70.28	-29.0	88.44
-163.0	33.27	-118.0	52.20	-73.0	70.68	-28.0	88.84
-162.0	33.69	-117.0	52.61	-72.0	71.09	-27.0	89.24
-161.0	34.12	-116.0	53.03	-71.0	71.50	-26.0	89.64
-160.0	34.54	-115.0	53.44	-70.0	71.90	-25.0	90.04
-159.0	34.97	-114.0	53.86	-69.0	72.31	-24.0	90.44
-158.0	35.40	-113.0	54.27	-68.0	72.72	-23.0	90.84
-157.0	35.82	-112.0	54.68	-67.0	73.12	-22.0	91.24
-156.0	36.25	-111.0	55.10	-66.0	73.53	-21.0	91.64

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
-20.0	92.04	25.0	109.89	70.0	127.50	115.0	144.87
-19.0	92.44	26.0	110.28	71.0	127.89	116.0	145.26
-18.0	92.84	27.0	110.67	72.0	128.28	117.0	145.64
-17.0	93.24	28.0	111.07	73.0	128.66	118.0	146.02
-16.0	93.63	29.0	111.46	74.0	129.05	119.0	146.41
-15.0	94.03	30.0	111.86	75.0	129.44	120.0	146.79
-14.0	94.43	31.0	112.25	76.0	129.83	121.0	147.17
-13.0	94.83	32.0	112.64	77.0	130.22	122.0	147.55
-12.0	95.23	33.0	113.03	78.0	130.60	123.0	147.94
-11.0	95.63	34.0	113.43	79.0	130.99	124.0	148.32
-10.0	96.02	35.0	113.82	80.0	131.38	125.0	148.70
-9.0	96.42	36.0	114.21	81.0	131.77	126.0	149.08
-8.0	96.82	37.0	114.61	82.0	132.15	127.0	149.47
-7.0	97.22	38.0	115.00	83.0	132.54	128.0	149.85
-6.0	97.62	39.0	115.39	84.0	132.93	129.0	150.23
-5.0	98.01	40.0	115.78	85.0	133.32	130.0	150.61
-4.0	98.41	41.0	116.18	86.0	133.70	131.0	150.99
-3.0	98.81	42.0	116.57	87.0	134.09	132.0	151.37
-2.0	99.21	43.0	116.96	88.0	134.48	133.0	151.76
-1.0	99.60	44.0	117.35	89.0	134.86	134.0	152.14
0.0	100.00	45.0	117.74	90.0	135.25	135.0	152.52
1.0	100.40	46.0	118.13	91.0	135.64	136.0	152.90
2.0	100.79	47.0	118.53	92.0	136.02	137.0	153.28
3.0	101.19	48.0	118.92	93.0	136.41	138.0	153.66
4.0	101.59	49.0	119.31	94.0	136.79	139.0	154.04
5.0	101.98	50.0	119.70	95.0	137.18	140.0	154.42
6.0	102.38	51.0	120.09	96.0	137.57	141.0	154.80
7.0	102.78	52.0	120.48	97.0	137.95	142.0	155.18
8.0	103.17	53.0	120.87	98.0	138.34	143.0	155.56
9.0	103.57	54.0	121.26	99.0	138.72	144.0	155.94
10.0	103.96	55.0	121.65	100.0	139.11	145.0	156.32
11.0	104.36	56.0	122.04	101.0	139.49	146.0	156.70
12.0	104.75	57.0	122.43	102.0	139.88	147.0	157.08
13.0	105.15	58.0	122.82	103.0	140.26	148.0	157.46
14.0	105.55	59.0	123.21	104.0	140.65	149.0	157.84
15.0	105.94	60.0	123.60	105.0	141.03	150.0	158.22
16.0	106.34	61.0	123.99	106.0	141.42	151.0	158.60
17.0	106.73	62.0	124.38	107.0	141.80	152.0	158.98
18.0	107.13	63.0	124.77	108.0	142.19	153.0	159.36
19.0	107.52	64.0	125.16	109.0	142.57	154.0	159.74
20.0	107.92	65.0	125.55	110.0	142.95	155.0	160.12
21.0	108.31	66.0	125.94	111.0	143.34	156.0	160.50
22.0	108.70	67.0	126.33	112.0	143.72	157.0	160.87
23.0	109.10	68.0	126.72	113.0	144.11	158.0	161.25
24.0	109.49	69.0	127.11	114.0	144.49	159.0	161.63

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
160.0	162.01	205.0	178.91	250.0	195.57	295.0	212.00
161.0	162.39	206.0	179.28	251.0	195.94	296.0	212.36
162.0	162.77	207.0	179.66	252.0	196.31	297.0	212.73
163.0	163.14	208.0	180.03	253.0	196.68	298.0	213.09
164.0	163.52	209.0	180.40	254.0	197.04	299.0	213.45
165.0	163.90	210.0	180.77	255.0	197.41	300.0	213.81
166.0	164.28	211.0	181.15	256.0	197.78	301.0	214.17
167.0	164.65	212.0	181.52	257.0	198.15	302.0	214.54
168.0	165.03	213.0	181.89	258.0	198.51	303.0	214.90
169.0	165.41	214.0	182.26	259.0	198.88	304.0	215.26
170.0	165.79	215.0	182.63	260.0	199.25	305.0	215.62
171.0	166.16	216.0	183.01	261.0	199.61	306.0	215.98
172.0	166.54	217.0	183.38	262.0	199.98	307.0	216.34
173.0	166.92	218.0	183.75	263.0	200.34	308.0	216.70
174.0	167.29	219.0	184.12	264.0	200.71	309.0	217.06
175.0	167.67	220.0	184.49	265.0	201.08	310.0	217.42
176.0	168.05	221.0	184.86	266.0	201.44	311.0	217.79
177.0	168.42	222.0	185.23	267.0	201.81	312.0	218.15
178.0	168.80	223.0	185.60	268.0	202.17	313.0	218.51
179.0	169.17	224.0	185.98	269.0	202.54	314.0	218.87
180.0	169.55	225.0	186.35	270.0	202.90	315.0	219.23
181.0	169.93	226.0	186.72	271.0	203.27	316.0	219.59
182.0	170.30	227.0	187.09	272.0	203.64	317.0	219.95
183.0	170.68	228.0	187.46	273.0	204.00	318.0	220.31
184.0	171.05	229.0	187.83	274.0	204.37	319.0	220.67
185.0	171.43	230.0	188.20	275.0	204.73	320.0	221.03
186.0	171.80	231.0	188.57	276.0	205.09	321.0	221.38
187.0	172.18	232.0	188.94	277.0	205.46	322.0	221.74
188.0	172.55	233.0	189.31	278.0	205.82	323.0	222.10
189.0	172.93	234.0	189.68	279.0	206.19	324.0	222.46
190.0	173.30	235.0	190.05	280.0	206.55	325.0	222.82
191.0	173.68	236.0	190.42	281.0	206.92	326.0	223.18
192.0	174.05	237.0	190.78	282.0	207.28	327.0	223.54
193.0	174.43	238.0	191.15	283.0	207.64	328.0	223.90
194.0	174.80	239.0	191.52	284.0	208.01	329.0	224.26
195.0	175.18	240.0	191.89	285.0	208.37	330.0	224.61
196.0	175.55	241.0	192.26	286.0	208.74	331.0	224.97
197.0	175.92	242.0	192.63	287.0	209.10	332.0	225.33
198.0	176.30	243.0	193.00	288.0	209.46	333.0	225.69
199.0	176.67	244.0	193.37	289.0	209.82	334.0	226.05
200.0	177.04	245.0	193.73	290.0	210.19	335.0	226.40
201.0	177.42	246.0	194.10	291.0	210.55	336.0	226.76
202.0	177.79	247.0	194.47	292.0	210.91	337.0	227.12
203.0	178.16	248.0	194.84	293.0	211.28	338.0	227.48
204.0	178.54	249.0	195.21	294.0	211.64	339.0	227.83

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
340.0	228.19	385.0	244.14	430.0	259.86	475.0	275.34
341.0	228.55	386.0	244.50	431.0	260.21	476.0	275.68
342.0	228.91	387.0	244.85	432.0	260.55	477.0	276.02
343.0	229.26	388.0	245.20	433.0	260.90	478.0	276.36
344.0	229.62	389.0	245.55	434.0	261.25	479.0	276.70
345.0	229.98	390.0	245.90	435.0	261.59	480.0	277.05
346.0	230.33	391.0	246.25	436.0	261.94	481.0	277.39
347.0	230.69	392.0	246.60	437.0	262.28	482.0	277.73
348.0	231.04	393.0	246.96	438.0	262.63	483.0	278.07
349.0	231.40	394.0	247.31	439.0	262.98	484.0	278.41
350.0	231.76	395.0	247.66	440.0	263.32	485.0	278.75
351.0	232.11	396.0	248.01	441.0	263.67	486.0	279.09
352.0	232.47	397.0	248.36	442.0	264.01	487.0	279.43
353.0	232.82	398.0	248.71	443.0	264.36	488.0	279.77
354.0	233.18	399.0	249.06	444.0	264.70	489.0	280.11
355.0	233.54	400.0	249.41	445.0	265.05	490.0	280.45
356.0	233.89	401.0	249.76	446.0	265.39	491.0	280.79
357.0	234.25	402.0	250.11	447.0	265.74	492.0	281.13
358.0	234.60	403.0	250.46	448.0	266.08	493.0	281.47
359.0	234.96	404.0	250.81	449.0	266.43	494.0	281.80
360.0	235.31	405.0	251.16	450.0	266.77	495.0	282.14
361.0	235.67	406.0	251.51	451.0	267.11	496.0	282.48
362.0	236.02	407.0	251.86	452.0	267.46	497.0	282.82
363.0	236.37	408.0	252.21	453.0	267.80	498.0	283.16
364.0	236.73	409.0	252.56	454.0	268.15	499.0	283.50
365.0	237.08	410.0	252.90	455.0	268.49	500.0	283.84
366.0	237.44	411.0	253.25	456.0	268.83	501.0	284.18
367.0	237.79	412.0	253.60	457.0	269.18	502.0	284.51
368.0	238.15	413.0	253.95	458.0	269.52	503.0	284.85
369.0	238.50	414.0	254.30	459.0	269.86	504.0	285.19
370.0	238.85	415.0	254.65	460.0	270.21	505.0	285.53
371.0	239.21	416.0	255.00	461.0	270.55	506.0	285.87
372.0	239.56	417.0	255.34	462.0	270.89	507.0	286.20
373.0	239.91	418.0	255.69	463.0	271.24	508.0	286.54
374.0	240.27	419.0	256.04	464.0	271.58	509.0	286.88
375.0	240.62	420.0	256.39	465.0	271.92	510.0	287.22
376.0	240.97	421.0	256.74	466.0	272.26	511.0	287.55
377.0	241.33	422.0	257.08	467.0	272.61	512.0	287.89
378.0	241.68	423.0	257.43	468.0	272.95	513.0	288.23
379.0	242.03	424.0	257.78	469.0	273.29	514.0	288.56
380.0	242.38	425.0	258.13	470.0	273.63	515.0	288.90
381.0	242.74	426.0	258.47	471.0	273.97	516.0	289.24
382.0	243.09	427.0	258.82	472.0	274.32	517.0	289.57
383.0	243.44	428.0	259.17	473.0	274.66	518.0	289.91
384.0	243.79	429.0	259.51	474.0	275.00	519.0	290.25

MINCO PRODUCTS, INC.

7300 Commerce Lane / Minneapolis, Minnesota 55432 U.S.A. / TWX: 910-576-2848 / Telephone: (612) 571-3121

RESISTANCE TEMPERATURE TABLE
EUROPEAN SPEC. $R_{100C}/R_{0C} = 1.3850$
PLATINUM RESISTANCE THERMOMETER
100 OHMS AT 0°C.

TABLE 5-100

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
-200	18.49	-150	39.71	-100	60.25	-50	80.31
-199	18.93	-149	40.13	-99	60.66	-49	80.70
-198	19.36	-148	40.55	-98	61.06	-48	81.10
-197	19.79	-147	40.96	-97	61.47	-47	81.50
-196	20.22	-146	41.38	-96	61.87	-46	81.89
-195	20.65	-145	41.79	-95	62.28	-45	82.29
-194	21.08	-144	42.21	-94	62.68	-44	82.69
-193	21.51	-143	42.63	-93	63.09	-43	83.08
-192	21.94	-142	43.04	-92	63.49	-42	83.48
-191	22.37	-141	43.45	-91	63.90	-41	83.88
-190	22.80	-140	43.87	-90	64.30	-40	84.27
-189	23.23	-139	44.28	-89	64.70	-39	84.67
-188	23.66	-138	44.70	-88	65.11	-38	85.06
-187	24.09	-137	45.11	-87	65.51	-37	85.46
-186	24.52	-136	45.52	-86	65.91	-36	85.85
-185	24.94	-135	45.94	-85	66.31	-35	86.25
-184	25.37	-134	46.35	-84	66.72	-34	86.64
-183	25.80	-133	46.76	-83	67.12	-33	87.04
-182	26.23	-132	47.18	-82	67.52	-32	87.43
-181	26.65	-131	47.59	-81	67.92	-31	87.83
-180	27.08	-130	48.00	-80	68.33	-30	88.22
-179	27.50	-129	48.41	-79	68.73	-29	88.62
-178	27.93	-128	48.82	-78	69.13	-28	89.01
-177	28.35	-127	49.23	-77	69.53	-27	89.40
-176	28.78	-126	49.64	-76	69.93	-26	89.80
-175	29.20	-125	50.06	-75	70.33	-25	90.19
-174	29.63	-124	50.47	-74	70.73	-24	90.59
-173	30.05	-123	50.88	-73	71.13	-23	90.98
-172	30.47	-122	51.29	-72	71.53	-22	91.37
-171	30.90	-121	51.70	-71	71.93	-21	91.77
-170	31.32	-120	52.11	-70	72.33	-20	92.16
-169	31.74	-119	52.52	-69	72.73	-19	92.55
-168	32.16	-118	52.92	-68	73.13	-18	92.95
-167	32.59	-117	53.33	-67	73.53	-17	93.34
-166	33.01	-116	53.74	-66	73.93	-16	93.73
-165	33.43	-115	54.15	-65	74.33	-15	94.12
-164	33.85	-114	54.56	-64	74.73	-14	94.52
-163	34.27	-113	54.97	-63	75.13	-13	94.91
-162	34.69	-112	55.38	-62	75.53	-12	95.30
-161	35.11	-111	55.78	-61	75.93	-11	95.69
-160	35.53	-110	56.19	-60	76.33	-10	96.09
-159	35.95	-109	56.60	-59	76.73	-9	96.48
-158	36.37	-108	57.00	-58	77.13	-8	96.87
-157	36.79	-107	57.41	-57	77.52	-7	97.26
-156	37.21	-106	57.82	-56	77.92	-6	97.65
-155	37.63	-105	58.22	-55	78.32	-5	98.04
-154	38.04	-104	58.63	-54	78.72	-4	98.44
-153	38.46	-103	59.04	-53	79.11	-3	98.83
-152	38.88	-102	59.44	-52	79.51	-2	99.22
-151	39.30	-101	59.85	-51	79.91	-1	99.61
-150	39.71	-100	60.25	-50	80.31	0	100.00

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
0	100.00	50	119.40	100	138.50	150	157.31
1	100.39	51	119.78	101	138.88	151	157.69
2	100.78	52	120.16	102	139.26	152	158.06
3	101.17	53	120.55	103	139.64	153	158.43
4	101.56	54	120.93	104	140.02	154	158.81
5	101.95	55	121.32	105	140.39	155	159.18
6	102.34	56	121.70	106	140.77	156	159.55
7	102.73	57	122.09	107	141.15	157	159.93
8	103.12	58	122.47	108	141.53	158	160.30
9	103.51	59	122.86	109	141.91	159	160.67
10	103.90	60	123.24	110	142.29	160	161.04
11	104.29	61	123.62	111	142.66	161	161.42
12	104.68	62	124.01	112	143.04	162	161.79
13	105.07	63	124.39	113	143.42	163	162.16
14	105.46	64	124.77	114	143.80	164	162.53
15	105.85	65	125.16	115	144.17	165	162.90
16	106.24	66	125.54	116	144.55	166	163.27
17	106.63	67	125.92	117	144.93	167	163.65
18	107.02	68	126.31	118	145.31	168	164.02
19	107.40	69	126.69	119	145.68	169	164.39
20	107.79	70	127.07	120	146.06	170	164.76
21	108.18	71	127.45	121	146.44	171	165.13
22	108.57	72	127.84	122	146.81	172	165.50
23	108.96	73	128.22	123	147.19	173	165.87
24	109.35	74	128.60	124	147.57	174	166.24
25	109.73	75	128.98	125	147.94	175	166.61
26	110.12	76	129.37	126	148.32	176	166.98
27	110.51	77	129.75	127	148.70	177	167.35
28	110.90	78	130.13	128	149.07	178	167.72
29	111.28	79	130.51	129	149.45	179	168.09
30	111.67	80	130.89	130	149.82	180	168.46
31	112.06	81	131.27	131	150.20	181	168.83
32	112.45	82	131.66	132	150.57	182	169.20
33	112.83	83	132.04	133	150.95	183	169.57
34	113.22	84	132.42	134	151.33	184	169.94
35	113.61	85	132.80	135	151.70	185	170.31
36	113.99	86	133.18	136	152.08	186	170.68
37	114.38	87	133.56	137	152.45	187	171.05
38	114.77	88	133.94	138	152.83	188	171.42
39	115.15	89	134.32	139	153.20	189	171.79
40	115.54	90	134.70	140	153.58	190	172.16
41	115.93	91	135.08	141	153.95	191	172.53
42	116.31	92	135.46	142	154.32	192	172.90
43	116.70	93	135.84	143	154.70	193	173.26
44	117.08	94	136.22	144	155.07	194	173.63
45	117.47	95	136.60	145	155.45	195	174.00
46	117.85	96	136.98	146	155.82	196	174.37
47	118.24	97	137.36	147	156.19	197	174.74
48	118.62	98	137.74	148	156.57	198	175.10
49	119.01	99	138.12	149	156.94	199	175.47
50	119.40	100	138.50	150	157.31	200	175.84

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
200	175.84	250	194.07	300	212.02	350	229.67
201	176.21	251	194.44	301	212.37	351	230.02
202	176.57	252	194.80	302	212.73	352	230.37
203	176.94	253	195.16	303	213.09	353	230.72
204	177.31	254	195.52	304	213.44	354	231.07
205	177.68	255	195.88	305	213.80	355	231.42
206	178.04	256	196.24	306	214.15	356	231.77
207	178.41	257	196.60	307	214.51	357	232.12
208	178.78	258	196.96	308	214.86	358	232.47
209	179.14	259	197.33	309	215.22	359	232.82
210	179.51	260	197.69	310	215.57	360	233.17
211	179.88	261	198.05	311	215.93	361	233.52
212	180.24	262	198.41	312	216.28	362	233.87
213	180.61	263	198.77	313	216.64	363	234.22
214	180.97	264	199.13	314	216.99	364	234.56
215	181.34	265	199.49	315	217.35	365	234.91
216	181.71	266	199.85	316	217.70	366	235.26
217	182.07	267	200.21	317	218.05	367	235.61
218	182.44	268	200.57	318	218.41	368	235.96
219	182.80	269	200.93	319	218.76	369	236.31
220	183.17	270	201.29	320	219.12	370	236.65
221	183.53	271	201.65	321	219.47	371	237.00
222	183.90	272	202.01	322	219.82	372	237.35
223	184.26	273	202.36	323	220.18	373	237.70
224	184.63	274	202.72	324	220.53	374	238.04
225	184.99	275	203.08	325	220.88	375	238.39
226	185.36	276	203.44	326	221.24	376	238.74
227	185.72	277	203.80	327	221.59	377	239.09
228	186.09	278	204.16	328	221.94	378	239.43
229	186.45	279	204.52	329	222.29	379	239.78
230	186.82	280	204.88	330	222.65	380	240.13
231	187.18	281	205.23	331	223.00	381	240.47
232	187.54	282	205.59	332	223.35	382	240.82
233	187.91	283	205.95	333	223.70	383	241.17
234	188.27	284	206.31	334	224.06	384	241.51
235	188.63	285	206.67	335	224.41	385	241.86
236	189.00	286	207.02	336	224.76	386	242.20
237	189.36	287	207.38	337	225.11	387	242.55
238	189.72	288	207.74	338	225.46	388	242.90
239	190.09	289	208.10	339	225.81	389	243.24
240	190.45	290	208.45	340	226.17	390	243.59
241	190.81	291	208.81	341	226.52	391	243.93
242	191.18	292	209.17	342	226.87	392	244.28
243	191.54	293	209.52	343	227.22	393	244.62
244	191.90	294	209.88	344	227.57	394	244.97
245	192.26	295	210.24	345	227.92	395	245.31
246	192.63	296	210.59	346	228.27	396	245.66
247	192.99	297	210.95	347	228.62	397	246.00
248	193.35	298	211.31	348	228.97	398	246.35
249	193.71	299	211.66	349	229.32	399	246.69
250	194.07	300	212.02	350	229.67	400	247.04

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
400	247.04	450	264.11	500	280.90	550	297.39
401	247.38	451	264.45	501	281.23	551	297.72
402	247.73	452	264.79	502	281.56	552	298.04
403	248.07	453	265.13	503	281.89	553	298.37
404	248.41	454	265.47	504	282.23	554	298.70
405	248.76	455	265.80	505	282.56	555	299.02
406	249.10	456	266.14	506	282.89	556	299.35
407	249.45	457	266.48	507	283.22	557	299.68
408	249.79	458	266.82	508	283.55	558	300.00
409	250.13	459	267.15	509	283.89	559	300.33
410	250.48	460	267.49	510	284.22	560	300.65
411	250.82	461	267.83	511	284.55	561	300.98
412	251.16	462	268.17	512	284.88	562	301.31
413	251.50	463	268.50	513	285.21	563	301.63
414	251.85	464	268.84	514	285.54	564	301.96
415	252.19	465	269.18	515	285.87	565	302.28
416	252.53	466	269.51	516	286.21	566	302.61
417	252.88	467	269.85	517	286.54	567	302.93
418	253.22	468	270.19	518	286.87	568	303.26
419	253.56	469	270.52	519	287.20	569	303.58
420	253.90	470	270.86	520	287.53	570	303.91
421	254.24	471	271.20	521	287.86	571	304.23
422	254.59	472	271.53	522	288.19	572	304.56
423	254.93	473	271.87	523	288.52	573	304.88
424	255.27	474	272.20	524	288.85	574	305.20
425	255.61	475	272.54	525	289.18	575	305.53
426	255.95	476	272.88	526	289.51	576	305.85
427	256.29	477	273.21	527	289.84	577	306.18
428	256.64	478	273.55	528	290.17	578	306.50
429	256.98	479	273.88	529	290.50	579	306.82
430	257.32	480	274.22	530	290.83	580	307.15
431	257.66	481	274.55	531	291.16	581	307.47
432	258.00	482	274.89	532	291.49	582	307.79
433	258.34	483	275.22	533	291.81	583	308.12
434	258.68	484	275.56	534	292.14	584	308.44
435	259.02	485	275.89	535	292.47	585	308.76
436	259.36	486	276.23	536	292.80	586	309.09
437	259.70	487	276.56	537	293.13	587	309.41
438	260.04	488	276.89	538	293.46	588	309.73
439	260.38	489	277.23	539	293.79	589	310.05
440	260.72	490	277.56	540	294.11	590	310.38
441	261.06	491	277.90	541	294.44	591	310.70
442	261.40	492	278.23	542	294.77	592	311.02
443	261.74	493	278.56	543	295.10	593	311.34
444	262.08	494	278.90	544	295.43	594	311.67
445	262.42	495	279.23	545	295.75	595	311.99
446	262.76	496	279.56	546	296.08	596	312.31
447	263.10	497	279.90	547	296.41	597	312.63
448	263.43	498	280.23	548	296.74	598	312.95
449	263.77	499	280.56	549	297.06	599	313.27
450	264.11	500	280.90	550	297.39	600	313.59

ENVIRONMENTAL EQUIPMENT WARRANTY

Purchaser

ELECTRO RENT CORP.

Model TJR

Serial No. 26040-21

P.O. No. 169825

The seller, TENNEY ENVIRONMENTAL, warrants that the equipment and materials manufactured under this contract are in accordance with TENNEY ENVIRONMENTAL specifications.

If any part of said equipment or material manufactured by TENNEY ENVIRONMENTAL, as determined by the seller, is defective in workmanship or material, and not subjected to misuse or abuse,

(1) within 90 days from date of installation or within 120 days from date of invoice, whichever period is the lesser, TENNEY ENVIRONMENTAL will exchange and install a replacement part in place and stead of the said defective part without charge,

(2) within a period beginning with the expiration of the above mentioned period and ending one year from date of invoice, TENNEY ENVIRONMENTAL will furnish an exchange part for the defective one, f.o.b. Seller's Plant, Williamsport, Pennsylvania, and installation and cost of installation thereof will be the responsibility of the customer.

Accessories and component parts not manufactured by TENNEY ENVIRONMENTAL shall be warranted to the extent of the original manufacturers' warranty. The main types of such components are compressors, expansion valves, relays, thermostats, limit controls, float valves, electric motors, receivers, vapor tanks, condensers, gauges, thermometers, and transformers on which the warranty is one year. On control instruments of all types, the manufacturer gives a one year warranty on originally defective parts as determined by factory inspection.

On all viewing windows, refrigerant, and paint finishes, no warranties are extended by the manufacturers, therefore, no warranty is extended by TENNEY ENVIRONMENTAL to the purchaser.

TENNEY ENVIRONMENTAL shall not be liable for any operation delays or consequential damages under this warranty. There shall be no other obligation expressed or implied.

7-22-97

Date

R Cook

Authorized by

Tenney ENVIRONMENTAL

4 Quality Street • Williamsport, PA • 17701

LUNAIRE LTD.

PARTS LIST

☐ GRUENBERG ☐ ENVIRONMENTAL
☐ TENNEY ☐ VISTA
☐ MECHANICAL ■ TENNEY
■ ELECTRICAL ☐ STRUCTURE
☐ REFRIG. ☐ SHEET
☐ OTHER ☐ PLUMBING

☐ ADD ☐ DELETE

JOB NO. _____ REV. __ 1 OF 1
CUSTOMER _____ MODEL TJR
☐ STANDARD PREPARED BY _____
☐ SPECIAL PICKED BY _____
☐ NONE APPROVED BY _____
☐ OTHER SHIP DATE _____

UNIT PER JOB ____ PICK DATE _____

R = REPAIR PART S = RECOMMENDED STOCK SPARE **** = LONG LEAD ITEM*

Part No.	Symbol	Description/Size	R/S	Qty.	P.O.	Comments
216301	AH1	HEATER, AIR ASSEMBLY:	R	1		
	AH2	500 Watt(.5KW) @ 115Volts				
213623	1MTR	MOTOR, CONDITIONER: 1/40 H.P.	R	1		
		3000 R.P.M., 115Vac-1phase				
213659	2MTR	MOTOR, CONDENSER: H.P. 9Watt	R	1		
		1550R.P.M., 115Vac-1phase				
		ENCLOSURE: TEAO				
201639	1SS	SWITCH, MAIN: DPST	S	1		
		CARLING SWITCH				
		GREEN"ON" LIGHT/RED LIGHT				
XXXXX		**CONTROLLER: SEE OPTION SHEET**				
213119		SENSOR, MINCO (RTD)	S	1		**FOR USE WITH**
						WATLOW 942
200097	1CR	RELAY: DPDT, 10AMPS 115V COIL	S	1		
200099		BASE, RELAY: 8 PIN (RAIL MOUNT)		1		
280503	1/2TRC	TRIAC: 40 AMP, 600Volt	S	2		
890021		BRACKET: TRIAC (SINGLE MOUNT)		1		
213347	HL	FUSE, HEAT LIMITER: BUSS# WKV	S	1		
270164		CORD, LINE with PLUG 12/3 (9ft.)		1		
281091	1/2FTR	RESISTOR/CAPACITOR (100ohm)		2		
281082	1/2R	RESISTOR, 100/Ohm, 1/2 Watt	S	2		
250535		TERMINAL BLOCK: 20A, 20 POINT		1		
280465		RECEPTACLE, 20A, 115V (SINGLE)		1		
280483		PLATE, COVER: (1 GANG SINGLE)		1		
890438		PLATE, COVER: BREAKER		1		
280809		BUSHING: ADALET 1/2" FEMALE		1		
280810		BUSHING: ADALET 1/2" MALE		1		
280615		CONNECTOR, 1/2" OUTLET RING		1		for flex guard

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PARTS LIST

☐ GRUENBERG ☐ ENVIRONMENTAL JOB NO. _____ REV. __ 1 OF 2

☐ TENNEY ☐ VISTA CUSTOMER _____ MODEL TJR

■ MECHANICAL ■ TENNEY ☐ STANDARD PREPARED BY _____

☐ ELECTRICAL ☐ STRUCTURE ☐ SPECIAL PICKED BY _____

☐ REFRIG. ☐ SHEET ☐ NONE APPROVED BY _____

☐ OTHER ☐ PLUMBING ☐ OTHER SHIP DATE _____

☐ ADD ☐ DELETE UNIT PER JOB ____ PICK DATE _____

R = REPAIR PART S = RECOMMENDED STOCK SPARE *** = LONG LEAD ITEM

Part No.	Symbol	Description/Size	R/S	Qty.	P.O.	Comments
122009		SHROUD, CONDENSER FAN, 1/16		1		
122007		BRACKET, COND. FAN MOTOR		1		
130005		SEAL: HEX, 1/8", #N9030-1/8"		4		
105220		BUSHING, CHASSIS: 3/8" W/NUT		4		
400021		NUT, BRASS: HEX 6-32 (LONG)		2		
100946		MULLION: 1/8" HAYSITE GRAD. (01)		1		
121307		GASKET: NEOPRENE, BLACK		1		(OUTER)
121309		GASKET: SILICONE, GRAY		1		(INNER)
101259		GUARD, FAN: S.S. (PRINT# 11393-01)		1		
101257		FAN BLADE: #0U931-5 (CW)		1		
105302		GROMMET, RUBBER: 5/16" ID X 9		5		
122010		CLIP, CONDENSER SHROUD, #70		6		
101256		FAN BLADE: #055275 (CCW)		1		
105255		STOPPER, RUBBER: 2-15/32 (TOP)		1		
121332		GASKET, CORK: 1-1/8"ID X 2" OD		1		
100701		HINGE: LOOSE JOINT 3 X 3 LEFT		1Pr.		
800703		32 CF LATCH INSTALLATION		1		
110468		NUT, PLUSNUT: ALUM, 1/4"-20		1		
110050		NUT, TINNERMAN: SPEED		1		
503286		TUBING, S.S.304: 2 1/4" DIA.		.375ft.		

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PARTS LIST

☐ GRUENBERG ☐ ENVIRONMENTAL JOB NO. _____ REV. _ 2 OF 2

☐ TENNEY ☐ VISTA CUSTOMER _____ MODEL TJR

■ MECHANICAL ■ TENNEY ☐ STANDARD PREPARED BY _____

☐ ELECTRICAL ☐ STRUCTURE ☐ SPECIAL PICKED BY _____

☐ REFRIG. ☐ SHEET ☐ NONE APPROVED BY _____

☐ OTHER ☐ PLUMBING ☐ OTHER SHIP DATE _____

☐ ADD ☐ DELETE UNIT PER JOB ____ PICK DATE _____

R = REPAIR PART S = RECOMMENDED STOCK SPARE ****** = LONG LEAD ITEM***

Part No.	Symbol	Description/Size	R/S	Qty.	P.O.	Comments
890091		PILASTER: STANDARD 48" LONG		0.8		
105100		BUSHING, SNAP: HEYCO 2119 B		3		
101725		INSULATION, FOIL FACED, 1" X		2.8		SQ. FOOT
101731		INSULATION, SOFT FG: 2" THK		8.4		SQ. FOOT
101756		INSULATION: FBX 601: 2" X 24"		13.2		SQ. FOOT
121380		TAPE, POLYURETHANE FOAM		6ft.		

LUNAIRE LTD.

PARTS LIST

☐ GRUENBERG ☐ ENVIRONMENTAL JOB NO. _____ REV. _ 1 OF 2
☐ TENNEY ☐ VISTA CUSTOMER _____ MODEL TJR
☐ MECHANICAL ■ TENNEY ☐ STANDARD PREPARED BY _____
☐ ELECTRICAL ☐ STRUCTURE ☐ SPECIAL PICKED BY _____
■ REFRIG. ☐ SHEET ☐ NONE APPROVED BY _____
☐ OTHER ☐ PLUMBING ☐ OTHER SHIP DATE _____

☐ ADD ☐ DELETE UNIT PER JOB ____ PICK DATE _____

R = REPAIR PART S = RECOMMENDED STOCK SPARE ****** = LONG LEAD ITEM***

Part No.	Symbol	Description/Size	R/S	Qty.	P.O.	Comments
896001		CASCADE CONDENSER ASSEMBLY		1		SEE PG. 2 for breakdown
306054	3/4MTR	COMPRESSOR: 1/2H.P. 115Vac, 150	R	2		C1/1(REF.) C2/2(REF.)
306225		COIL, COOLING: 3CZ1004A 4 X 8		1		
306231		COIL, CONDENSER: TJR 60294	R	1		
301276	PS1	SWITCH, PRESSURE: OPEN 18lbs.	S	1		
301277	PS2	SWITCH, PRESSURE: OPEN 240lbs. P20	S	1		
300375	AV	VALVE, ACCESS: 3/8" OD JB A31	R	4		
300389	VC	VALVE, ACCESS: JB A31720-32	R	2		
301300	CAP	CAP, PRESSURE: P20 SERIES 2	R	2		
400474		CAP, SCREW: HH 1/4-20 X 1" LG.		4		
300111		ELBOW, CU: 45D 3/8" ODS		1		MUELLER
890570		1 1/8" OD COPPER TUBE X 4		1		
300012		TUBE, CU: 1/4" OD (REFRIG.)		11		
300013		TUBE, CU: 5/16" OD (REFRIG.)		6		
300014		TUBE, CU: 3/8" OD (REFRIG.)		7		
101686		INSULATION: ARMAFLEX, 3/8" ID		1		

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PARTS LIST

☐ GRUENBERG ☐ ENVIRONMENTAL
☐ TENNEY ☐ VISTA
☐ MECHANICAL ■ TENNEY
☐ ELECTRICAL ☐ STRUCTURE
■ REFRIG. ☐ SHEET
☐ OTHER ☐ PLUMBING

JOB NO. _____ REV. _ 2 OF 2
CUSTOMER _____ MODEL TJR
☐ STANDARD PREPARED BY _____
☐ SPECIAL PICKED BY _____
☐ NONE APPROVED BY _____
☐ OTHER SHIP DATE _____

☐ ADD ☐ DELETE UNIT PER JOB ___ PICK DATE _____

R = REPAIR PART S = RECOMMENDED STOCK SPARE *** = LONG LEAD ITEM

Part No.	Symbol	Description/Size	R/S	Qty.	P.O.	Comments
		CASCADE/CONDENSER ASSEMBLY				
		(896001)				
302058	SLA	ACCUMULATOR: 3/8" (13)	S	1		
301227	SV1	VALVE, SOLENOID: 3/8" OD	R	1		
302013	D1	DRIER, CAP ASSEMBLY: 1060	S	1		
302048	EXT	TANK, EXPANSION: #0545	R	1		
300234		TEE, CU: 1/2" ODS X 1/4" OD		1		
300012		TUBE, CU: 1/4" OD (REFRIG.)		1		
300014		TUBE, CU: 3/8" OD (REFRIG.)		3		
299999	CAP	TUBE, CAP: .080 X .145		4		
896000		CASCADE CONDENSER COIL	R	1		
302035	D2	DRIER, CAP ASSEMBLY: 0930	S	1		
300366		BUSHING, CU: 3/8" FTG. X 1/4"		1		

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PARTS LIST

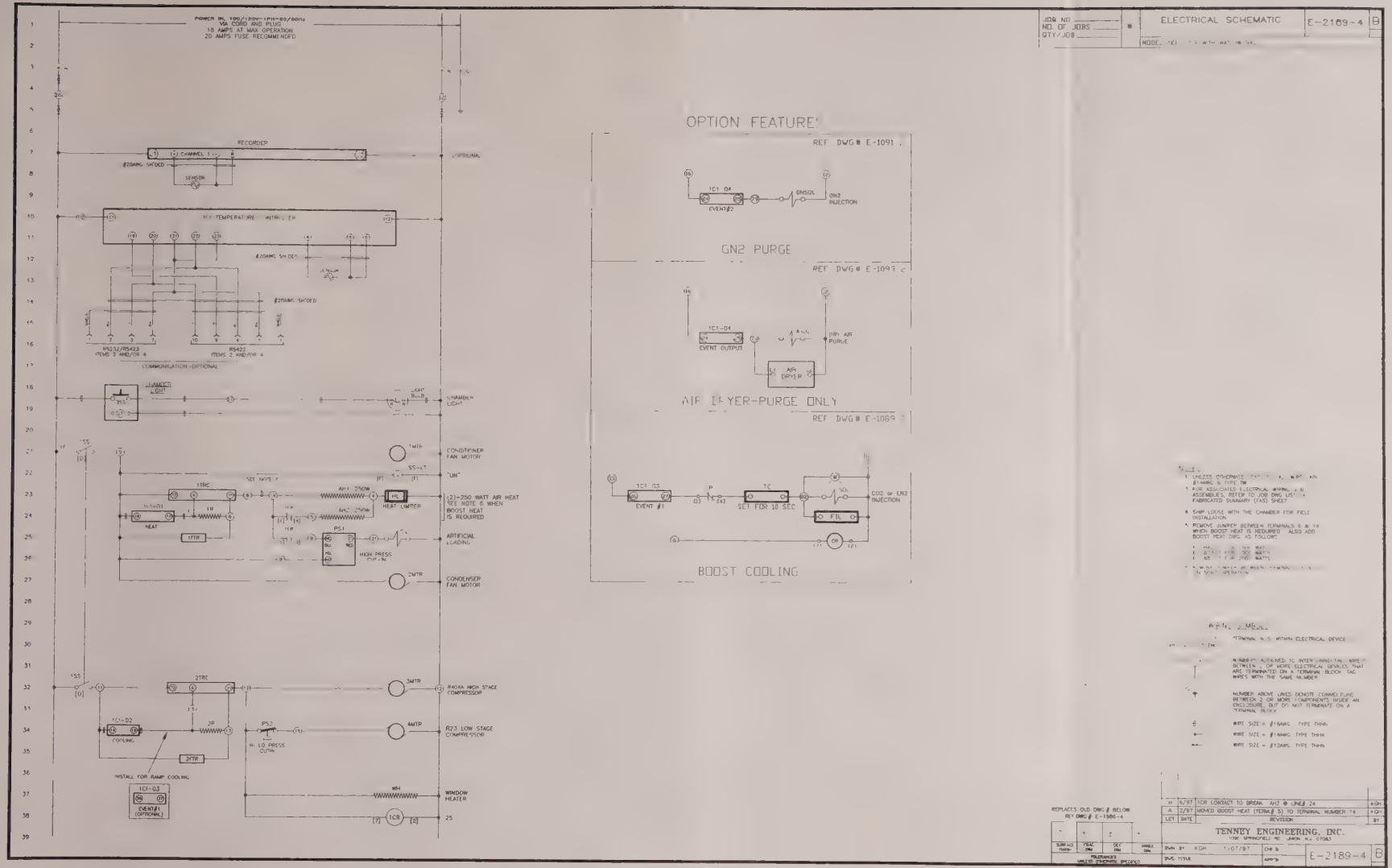
☐ GRUENBERG ☐ ENVIRONMENTAL
☐ TENNEY ☐ VISTA
☐ MECHANICAL ■ TENNEY
■ ELECTRICAL ☐ STRUCTURE
☐ REFRIG. ☐ SHEET
☐ OTHER ☐ PLUMBING

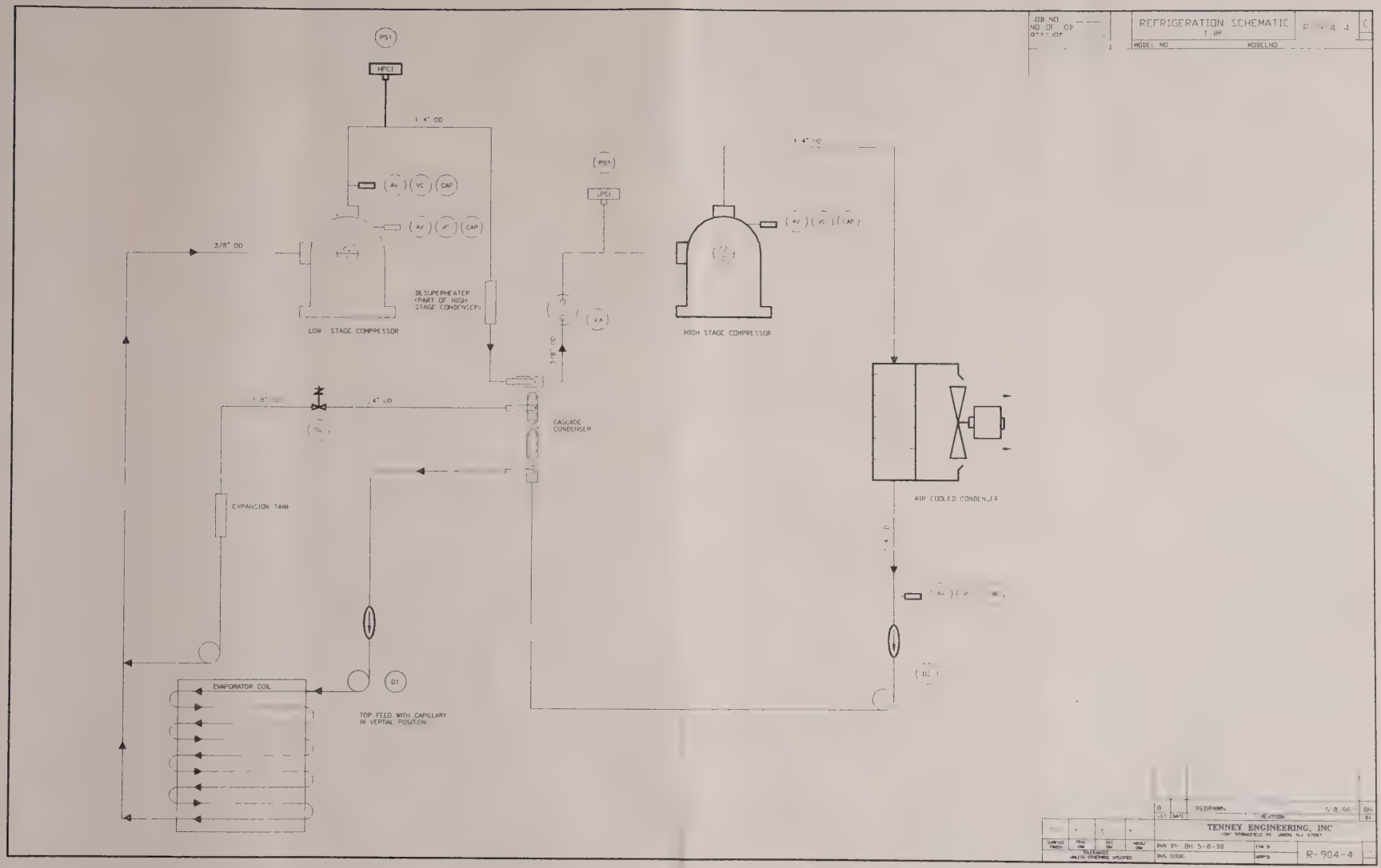
JOB NO. _____ REV. __ 1 OF 1
CUSTOMER _____ MODEL TJR
☐ STANDARD PREPARED BY _____
☐ SPECIAL PICKED BY _____
☐ NONE APPROVED BY _____
☐ OTHER SHIP DATE _____

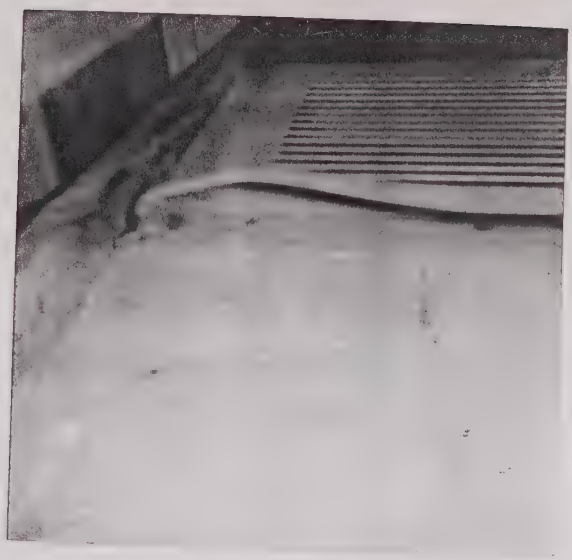
☐ ADD ☐ DELETE UNIT PER JOB ____ PICK DATE _____

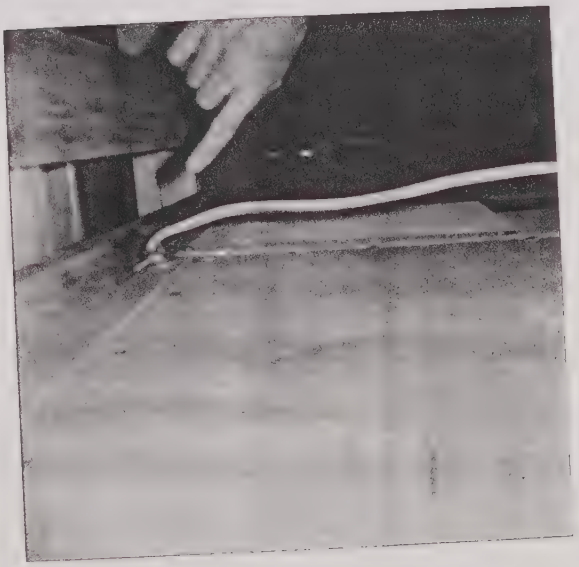
R = REPAIR PART S = RECOMMENDED STOCK SPARE **** = LONG LEAD ITEM*

Part No.	Symbol	Description/Size	R/S	Qty.	P.O.	Comments
		WATLOW CONTROLLER OPTIONS:				
213313		CONTROLLER: WATLOW	R			NO OPTIONS
		#942A-3KD0-AE00				
213314		CONTROLLER: WATLOW	R			RS232
		#942A-3KD0-BE00				
213315		CONTROLLER: WATLOW	R			WITH EVENTS
		942A-3KD2-AE00				
213316		CONTROLLER: WATLOW	R			COMM. & EVENTS
		942A-3KD2-BE00				
213119		SENSOR: RTD MINCO (DIN CURVE)	S			1 REQUIRED
						PER CONTROL


POWER IN, 100/120V~1PH~50/60Hz
VIA CORD AND PLUG
15 AMPS AT MAX OPERATION
20 AMPS FUSE RECOMMENDED
RECORDER
OPTIONAL
#20AWG SHIELDED
SENSOR
TEMPERATURE INTERFACER
#20AWG SHIELDED
#20AWG SHIELDED
RS232/RS423
ITEMS 2 AND/OR 4
RS422
ITEMS 2 AND/OR 4
COMMUNICATION-OPTIONAL
CHAMBER LIGHT
CONDITIONER FAN MOTOR
"UN"
(2)-250 WATT AIR HEAT
SEE NOTE 6 WHEN
BOOST HEAT
IS REQUIRED
ARTIFICIAL LOADING
CONDENSER FAN MOTOR
R404A HIGH STAGE COMPRESSOR
R23 LOW STAGE COMPRESSOR
WINDOW HEATER
COOLING
INSTALL FOR PUMP COOLING
EVENT#1
(OPTIONAL)
OPTION FEATURE
REF DWG# E-1091
EVENT#2
GN2 INJECTION
GN2 PURGE
REF DWG# E-1093
EVENT OUTPUT
DRY AIR PURGE
AIR DRYER
AIR DRYER-PURGE ONLY
REF DWG# E-1089
EVENT #1
SET FOR 10 SEC
CO2 or LN2 INJECTION
BOOST COOLING
ELECTRICAL SCHEMATIC
E-2189-4
B
TENNEY ENGINEERING, INC.


REFRIGERATION SCHEMATIC
TJRF
R-904-J
MODEL NO
MODEL NO
PS1
HPCI
1.4" OD
AV
VC
CAP
PS1
LPCI
3/8" OD
DESUPERHEATER
(PART OF HIGH
STAGE CONDENSER)
LOW STAGE COMPRESSOR
HIGH STAGE COMPRESSOR
3/8" OD
.4" OD
CASCADE
CONDENSER
EXPANSION TANK
AIR COOLED CONDENSER
EVAPORATOR COIL
TOP FEED WITH CAPILLARY
IN VERTIAL POSITION
REDRAWN
TENNEY ENGINEERING, INC
UNION NJ
DWN BH 5-8-96
R-904-4





Series 942

User's Manual

TOTAL
CUSTOMER SATISFACTION

1/4 DIN Microprocessor-Based Ramping Control

WATLOW

Watlow Controls

1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Phone: 507/454-5300, Fax: 507/452-4507

W942-XUMN Rev. R00
June, 1995
Supersedes:
W942-MA40-9305

$10.00
Made in the U.S.A.
Printed on Recycled Paper

Use The Manual

How to Use the Manual

Starting Out	Chapter 1, Page 4.	*• General Description*	*• Opening the 942*	*• Setting DIP Switches*	
Install/Wire	Chapter 2, Page 7.	*• Panel Cutout*	*• Dimensions*	*• Power, Inputs, Outputs, Auxiliary*	
Front Panel	Chapter 3, Page 21.	*• Key Func tions*	*• Displays & LEDs*	*• Front Panel Locking Screw*	
Setup	Chapter 4, Page 22.	*• Setup Menu*	*• Operation Menu*	*• Parameter Tables*	
Programming	Chapter 5, Page 31.	*• Program Menu*	*• Run Menu*	*• Master Step Chart*	*• Sample Program*
Tuning	Chapter 6, Page 40.	*• Auto-tuning*	*• Auxiliary Jumper*	*• Alarms*	*• Error Codes*
Appendix	Page 46.	*• Specifications*	*• Model Number*	*• Noise Guidelines*	*• Calibration*

Notes

This user's manual contains informational notes to alert you to important details. When you see a note icon, look for an explanation in the margin.

♪ or ♫

NOTE: Details of a "Note" appear here, in the narrow box on the outside of each page.

Safety Information

This user's manual also has **boldface** safety information notes to protect both you and your equipment. Please be attentive to them. Here are explanations:

The CAUTION symbol (exclamation point) in the wide text column alerts you to a **"CAUTION,"** a safety or functional hazard which could affect *your equipment* or its performance.

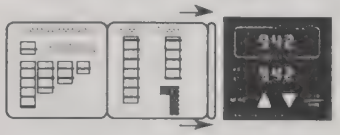
WARNING: Details of a "Warning" appear here, in the narrow box on the outside of each page.

The WARNING symbol (lightning bolt) in the wide text column alerts you to a **"WARNING,"** a safety hazard which could affect *you and the equipment.*

CAUTION: Details of a "Caution" appear here, in the narrow box on the outside of each page.

Quick Reference Card

The Series 942 control is shipped to you with a quick reference card seated in the front panel bezel. Pull the small tab to remove the card from the bezel. Notice that the back side of the tab has a strip of adhesive tape attached. To keep the card handy and near the control at all times, simply remove the backing on the adhesive, and apply the card to the front panel as shown.



Technical Assistance

If you encounter a problem with your Watlow control, review all of your configuration information to verify that your selections are consistent with your application... Inputs, Outputs, Alarms, Limits, etc. If the problem persists after checking the above, you can get technical assistance by dialing: 1-507-454-5300

An Application Engineer will discuss your problem with you. Please have the following information available when calling:

- Complete model number (located on outside of case)
- All configuration information
- Serial Number (located on outside of case)
- User's Manual

Your Feedback

Comments or suggestions on this manual are welcome, send them to: Technical Writer, Watlow Controls, 1241 Bundy Blvd., Winona, MN 55987, or phone 507/454-5300. The Watlow Series 942 User's Manual and integral software are copyrighted by Watlow Winona, Inc., © 1991, with all rights reserved.

WATLOW

Engineering Bulletin

#89.4.3

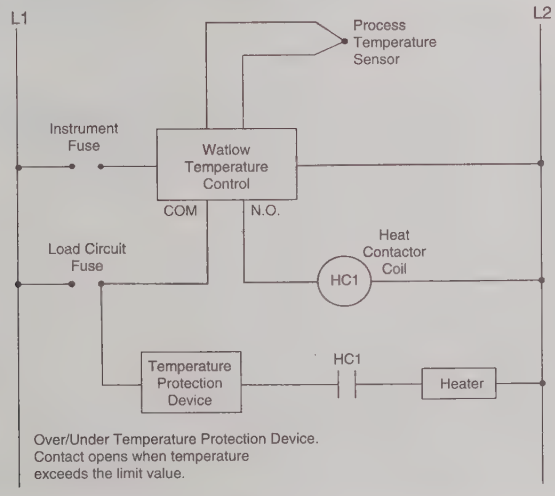
Over/Undertemperature Protection

Failure of components in a temperature control loop, such as the sensor, heater control relay, or main temperature control, can result in damage to a product in process, a meltdown of a heater, and/or a damaging fire.

To protect against this possibility, over/undertemperature protection must be provided to interrupt or remove power from the heater circuit. A "thermal fuse line" at the heater, or a "mechanical thermoswitch" at the heater are examples of recommended over/under temperature protection. For precise, repeatable limit protection, an "electronic limit control" may be used. We recommend the temperature protection device have UL, CSA, or FM approval, and be applied in the classification for which it was tested and approved. An example of a single phase wiring line diagram appears below.

WARNING

Install high or low temperature control protection in systems where an overtemperature or undertemperature fault condition could present a fire hazard or other hazard. Failure to install temperature control protection where a potential hazard exists could result in damage to equipment and property, and injury to personnel.



Further information is available from Watlow Controls; ask for application assistance.

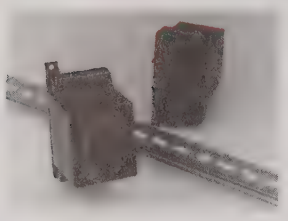
Disclaimer of Warranty

This document is a presentation of a general overview and statement of the safety-related need for and method of applying "over/undertemperature protection." Because of the diversity of conditions and hazards under which control products may be applied and because of the differences in components and methods of their installation, **no representation or warranty of any kind, express or implied, is hereby made**, that the limit control protection discussed and presented herein will be effective in any particular application or set of circumstances, or that additional or different precautions will not be reasonably necessary for a particular application. We will be pleased to consult with any customer regarding a specific application upon written request.

Watlow Controls, 1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Ph: 507-454-5300, Fax: 507-452-4507

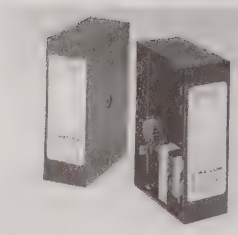
Limit Controls from Watlow

TOTAL CUSTOMER SATISFACTION



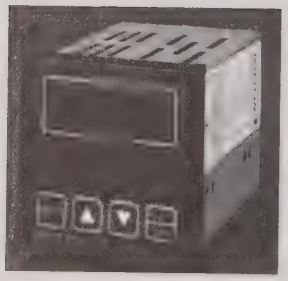
Series 92 - UL & FM Approved DIN Rail Mounted Limit

- Compact, finger/palm-safe design
- Latching limit (factory set as heat or cool) or temperature control
- Internal latching reset for a customer-supplied reset switch
- Operating environment:
  - 32 to 140°F (0 to 60°C)
  - 0 to 90% RH, non-condensing
- Agency Approvals
  - UL®873, File #E43684
  - FM 3545, J.I. ØY6A4.AF
  - CSA C22.2 #24-93, File #LR30586
  - Submitted for CE testing



Series 142 - UL Recognized Safety Limit

- Environmentally protected
- Compact sub-panel mounting
- Backup limit protection
- Factory fixed set point
- Operating environment:
  - 32 to 130°F (0 to 54°C)
  - 0 to 90% RH, non-condensing
- Agency Approvals
  - UL®197, 873, 991, File #E43684
  - CSA C22.2 #24-1987, File #LR30586
  - A.G.A., File 23-1C1



Series 945 - UL Recognized High-Low Limit

- 1/4 DIN microprocessor-based limit controller
- Wide range of input types
- Set point range limiting
- Dual limit control outputs
- Three operator lock-out levels
- Operating environment:
  - 32 to 149°F (0 to 65°C)
  - 0 to 90% RH, non-condensing
- Agency Approvals
  - UL®873 File #E43684
  - FM 3545, J.I. ØY6A4.AF

Your Authorized Watlow Distributor is:

WATLOW

Watlow Controls

1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Ph: 507-454-5300, Fax: 507-452-4507

WLCS-XSBN Rev A00
Mar. 96

Printed on Recycled Paper

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Chapter 1

The Watlow Series 942, A Microprocessor-Based Control

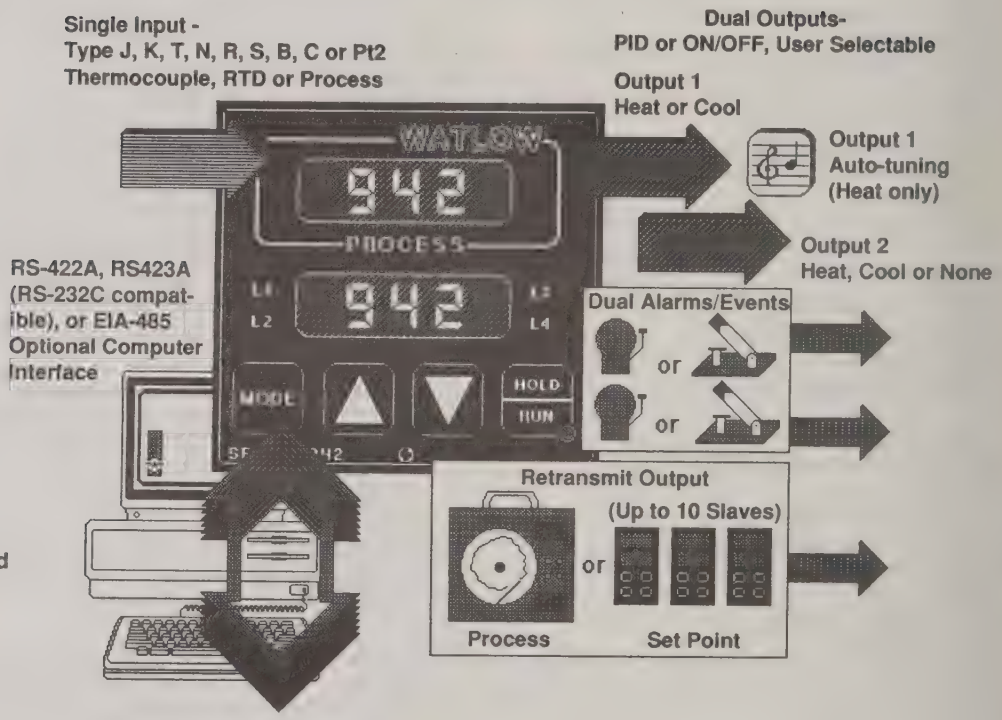


Figure 1 - Series 942 Input and Output Overview.

General Description

Welcome to the Watlow Series 942, a 1/4 DIN microprocessor-based ramping temperature control. It is a single input, dual output, auto-tuning control with 24 step program capability and easy fixed set point operation. The 942 accepts a Type J, K, T, N, R, S, B, C or Platinel 2 thermocouple, RTD, or process input. The primary output is heating or cooling, while the secondary output can be heating, cooling or none.

With the Series 942 you can select either PID or ON/OFF for Output 1 or 2. You can input a complete set of PID parameters for both outputs, including proportional band, reset/integral and rate/derivative. You can also select automatic tuning for Output 1 while in the heating mode. By setting either output's proportional band to zero, the Series 942 becomes a simple ON/OFF control with the switching differential selectable under the HYS Setup parameter.

Two optional auxiliary outputs may be alarms or events. An event is an ON/OFF mechanical relay output. Events are based on time, and can trigger peripheral equipment or processes. An optional retransmit output is offered in lieu of one of the auxiliary outputs. Select either retransmit of process variable or set point.

Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. The Watlow Series 942 automatically stores all information in a non-volatile memory.

How to Open the 942

Before going further, open the Series 942 and pull the control chassis from its case. Here's how:

The control chassis fastens to the case with a single standard screw located on the

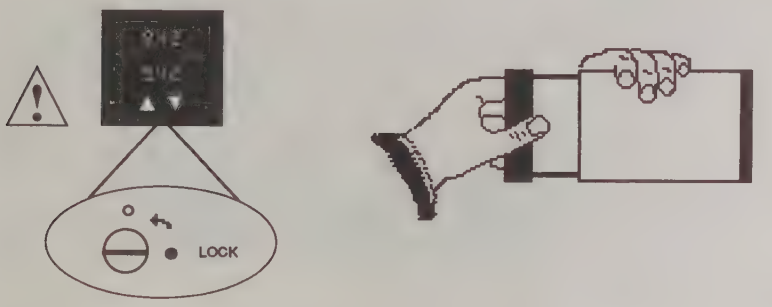


Figure 2 - How to Open the Series 942.

WARNING: The front panel screw turns 90° only. Do not apply excessive force or turn the screw more than 90°.

Three strip connector plugs, in the rear of the control chassis, feed power and signals through the back of the case to the terminal strips. These plugs will let go as you pull.

When removing the Series 942 control from its case, pull firmly but gently. When returning the control to the case, be sure you have the top up to match the plugs with the case. The 942 will not fit in the case upside down, but check to be sure it is oriented correctly. Press the unit in firmly, then turn the front panel screw clockwise to secure it. This insures proper electrical contact.

How to Set the DIP Switches

The Watlow Series 942 has a Dual In-line Package (DIP) switch inside the control on the A007-1954 circuit board (middle board). The location of the board and switch appear below. The switches are clearly numbered. When Switch #1 is ON, the Setup parameters can be viewed but not changed. When Switch #2 is ON, it provides battery backup of the Run parameters. When the control leaves the factory, both switches are OFF.

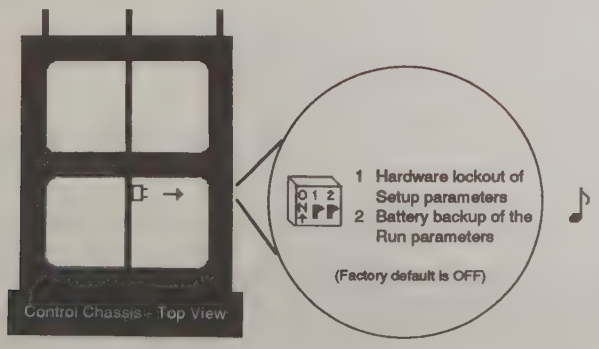

1 2
ON
1 Hardware lockout of Setup parameters
2 Battery backup of the Run parameters
(Factory default is OFF)
Control Chassis - Top View

Figure 3 - DIP Switch Location and Orientation.

NOTE: The lithium battery has a life of approximately ten years. When the battery expires, Pout and Run are affected (see Chapters 4 & 5). Return the unit to the factory for a replacement.

Chapter 2

How to Install and Wire the Series 942

System Planning

This chapter tells you how to install the Series 942. All mounting and wiring information is right here. Because Watlow controls are thoroughly tested and "burned in" before leaving the factory, the Series 942 is ready to install when you receive it.

But before you begin working, read through this chapter to gain an understanding of the entire installation. Consider sensor installation carefully. For detailed information you'll need to look at the noise reduction guidelines in the Appendix of this manual before making your panel cutout.

Installation Information

The Series 942 mounts in a panel cutout with two brackets, shipped with your control. These brackets hold the case against the front panel. The Series 942 behind-panel dimensions are 3.6" (90 mm) high by 3.6" (90 mm) wide by 6" (152 mm) deep. Figure 5 on the next page shows the dimensions of the front panel bezel. The 942 weighs 2.75 lbs. (1.25 kg) max.

For dimensional and mounting information, including the location of mounting brackets and size of the front panel cutout, see Figures 5 through 7 on the next page. Your panel's thickness can be from 0.06" (1.5 mm) to 0.25" (6.3 mm).

Installation Procedure

NOTE:
Removing the Series 942 chassis from its case may make mounting easier.

Follow this procedure to mount the Watlow Series 942 Temperature Control:

1. Make a panel cutout per the dimensions in Figure 6.
2. Remove the 942 from its case by turning the front panel screw 90° counter-clockwise (CCW). Grip the bezel firmly and pull the control chassis out of the case.

WARNING:
The front panel screw turns 90° only. Do not apply excessive force or turn the screw more than 90°.

3. Place the case in the cutout you just made.
4. Attach the mounting brackets either to the top and bottom, or to both sides of the unit.
5. Tighten the mounting brackets securely against your panel.
6. Insert the control chassis into its case and press the bezel to seat it. Turn the front panel screw 90° clockwise (CW) to lock the control in place. The hardware installation is complete. Proceed to the wiring section from here.

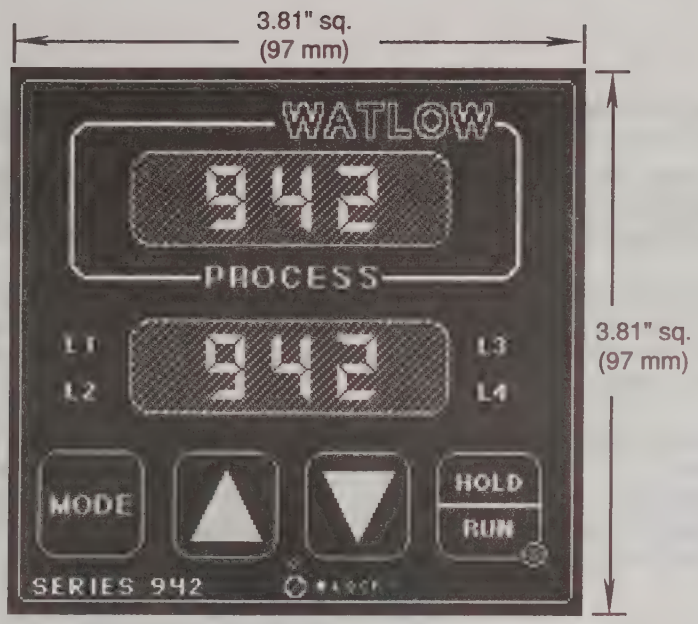
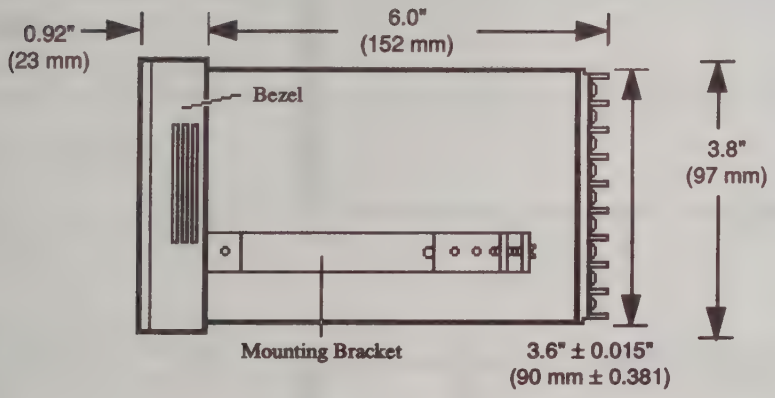


Figure 4 - Series 942 Dimensions.



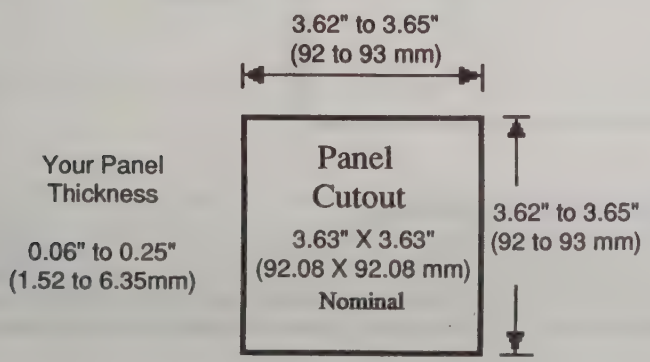


Figure 5 - Series 942 Panel Cutout Dimensions.

How to Wire the Series 942

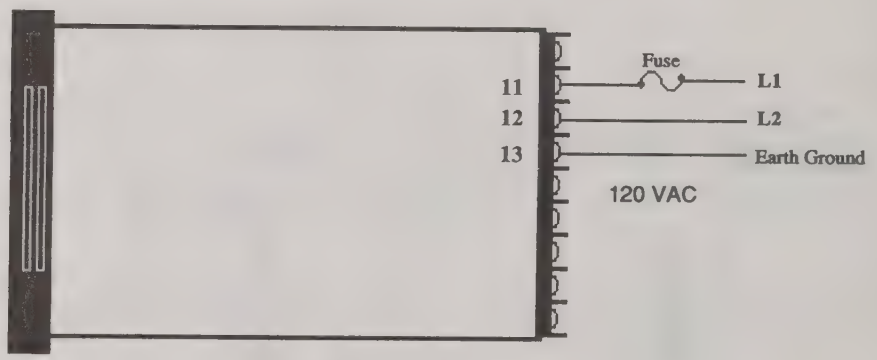
The Series 942 wiring is illustrated by model number option. **Check the terminal designation sticker** on the control and compare your model number to those shown here and to the model number breakdown in the Appendix of this manual.

NOTE:
For 50 or 60Hz operation, no adjustment or jumper placement is necessary.

Series 942 internal circuits appear "inside" the line drawing of the 942, while connections and terminal designations appear "outside" the line drawing. All outputs are referenced to a de-energized state. The final wiring figure is a typical system example.

When you apply power without sensor inputs on the terminal strip, the Series 942 displays "- - - -" in the Upper display, and Er7 in the Lower display. This error indicates an open sensor or A/D error. Remove power to the control and connect the sensor properly, see Page 10. All wiring and fusing must conform to the National Electric Code and to any locally applicable codes as well.

Figure 6 - 120 VAC Power Wiring.



CAUTION:
To avoid potential electric shock, use National Electric Code (NEC) safety practices when wiring and connecting this unit to a power source and to electrical sensors or peripheral devices.

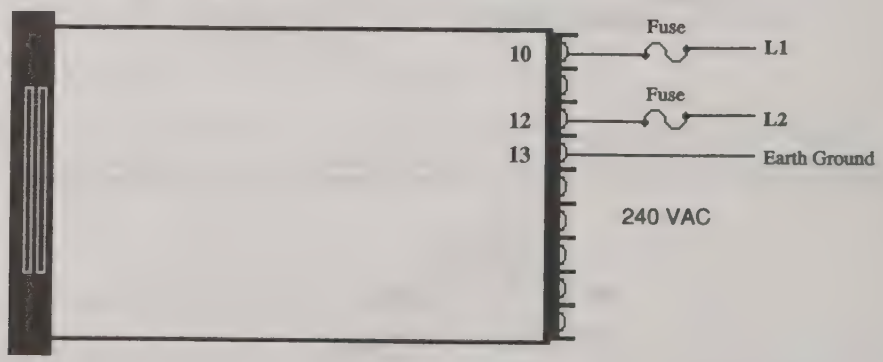


Figure 7 - 240 VAC Power Wiring.

Sensor Installation Guidelines

We suggest you mount the sensor at a location in your process or system where it reads an average temperature. Put the sensor as near as possible to the material or space you want to control. The sensor should be thermally insulated from the sensor mounting.

Thermocouple Input

Model # 942A - **1** _ _ _ - _ 000 942A - **3** _ _ _ - _ 000
942A - **2** _ _ _ - _ 000 942A - **4** _ _ _ - _ 000

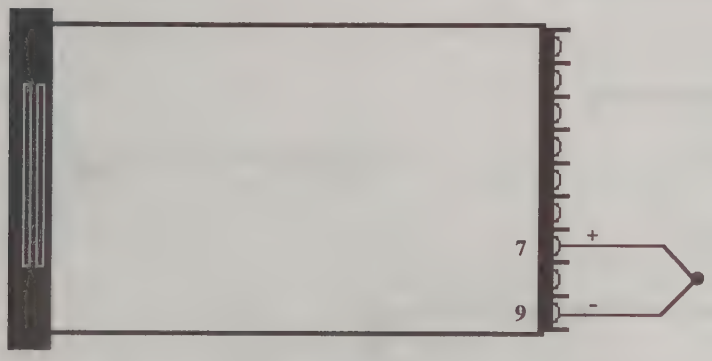


Figure 8 - Thermocouple Input Wiring.

You must use an isolated or ungrounded thermocouple, if an external device with a non-isolated circuit common is connected to the 4-20mA or 0 - 5VDC output.

Extension wire for thermocouples must be of the same alloy as the thermocouple itself to limit errors.

RTD, 2 or 3 Wire

Model # 942A - **2** _ _ _ - _ 000 942A - **3** _ _ _ - _ 000

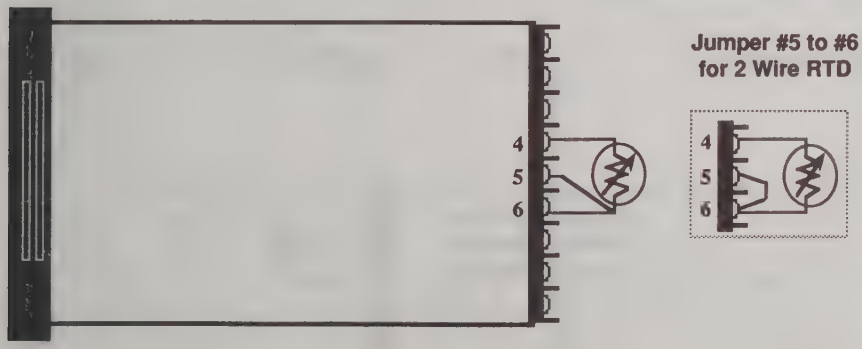


Figure 9 - 2 or 3 wire RTD Input Wiring.

Long lead lengths create electrical resistance. There will be approximately +2°C input error for every 1Ω of lead length resistance, when using a two wire RTD. The resistance, when added to the resistance of the RTD element, will result in erroneous input to the instrument. To overcome this problem, use a three wire RTD sensor, which compensates for lead length resistance. When extension wire is used for a three wire RTD, all three extension wires must have the same electrical resistance. (i.e. same gauge, copper stranded).

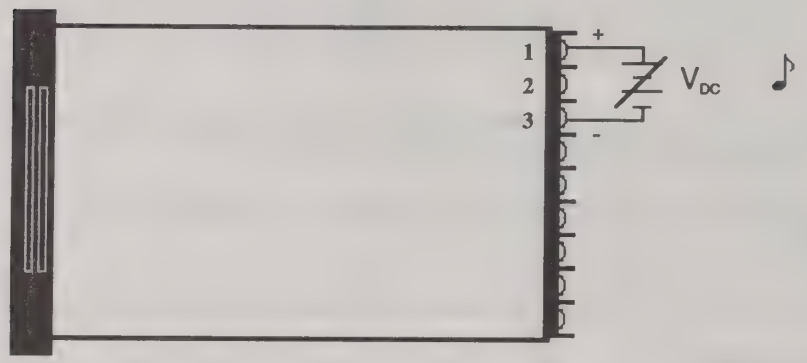
When using a process input such as 0 - 5VDC or 4 - 20mA, the rL and rH settings scale the display to match the measured range of the process signal.

An example of this is: A pressure transducer operates over a range of 0 - 300 PSI, delivering a 4 - 20mA output signal for this range. By setting rL = 0 and rH = 300, the Series 942 now displays a direct reading of pressure.

0 - 5VDC Process Input

Model # 942A - **2** _ _ _ - _ 000 942A - **3** _ _ _ - _ 000

Figure 10 - 0 - 5VDC Process Input Wiring.

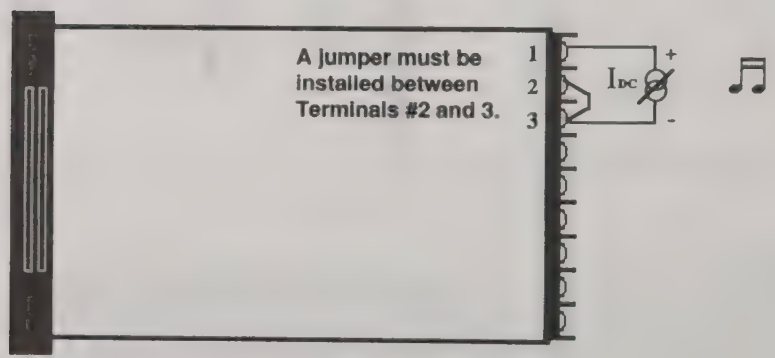


♪ **NOTE:**
When using a 0 - 5VDC process input, the input impedance is 100KΩ.

4 - 20mA Process Input

Model # 942A - **2** _ _ _ - _ 000 942A - **3** _ _ _ - _ 000

Figure 11 - 4 - 20mA Process Input Wiring.



♫ **NOTE:**
When using a 4 - 20mA process input, the input impedance is 249Ω.

Solid State Relay With Contact Suppression, Output 1

Model # 942A - _ **B** _ _ - _ 000

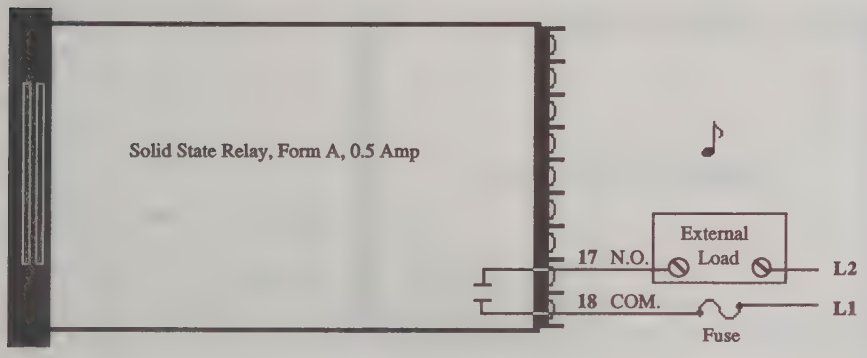


Figure 12 - Solid State Relay With Contact Suppression, Output 1 Wiring.

NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Solid State Relay With Contact Suppression
Watlow's solid state relay changes state at zero volts, which is "zero-cross switching." They are also optically isolated, which means the output circuitry is energized by infrared light striking a photosensitive device. This results in a virtual absence of electrically generated noise, and provides electrical isolation between the input and output. For use in switching mercury relays or small AC loads. **Off state impedance is 20KΩ minimum.**

Switched DC Output (Open Collector), Output 1

Model # 942A - _ **C** _ _ - _ 000

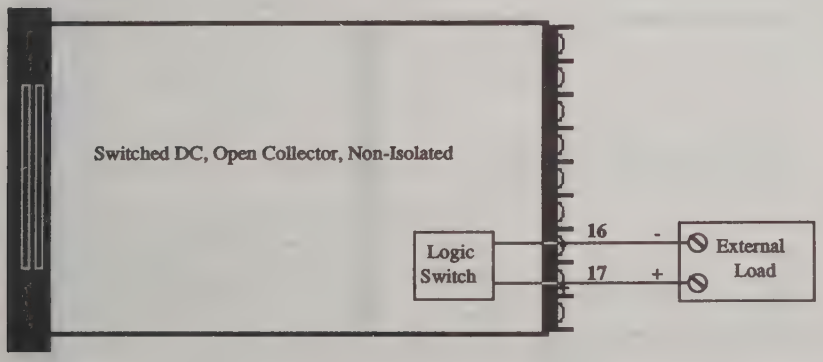


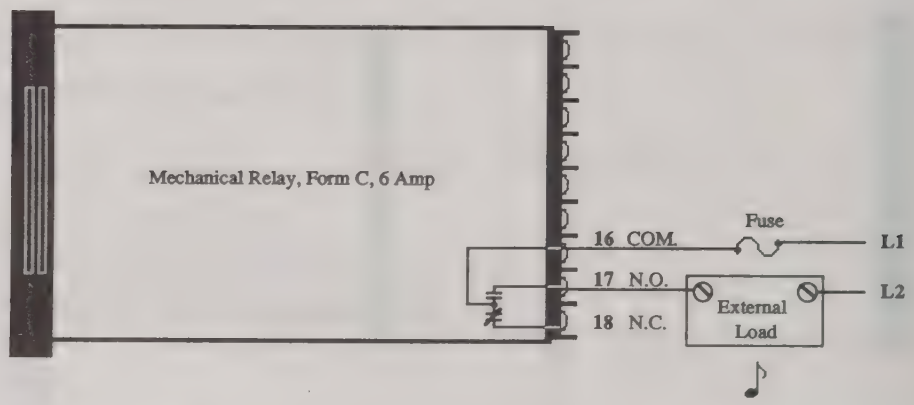
Figure 13 - Switched DC (Open Collector), Output 1 Wiring.

Switched DC
Watlow's solid state switch is a low current DC output (open collector) used to switch an external power switching device such as an SSR or an electromechanical relay. The input specifications of the power switching device must match those listed for the SS switch output. The power switching device must provide isolation between the SS switch output and load power since the SS switch output is a non-isolated output. Minimum load resistance is 500Ω. Available current is 22mA maximum. Typical voltage drop across a 1KΩ load is 12 to 19 volts.

Mechanical Relay, 6 Amp, Form C, Output 1

Model # 942A - _ **D** _ _ - _ 000

Figure 14 - 6 Amp Mechanical Relay, Output 1 Wiring.



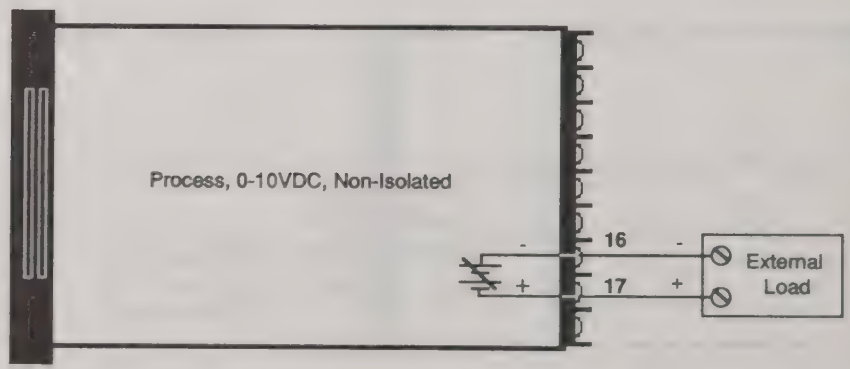
NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Mechanical Relay
The electromechanical relay is an electrical and mechanical device with moving parts. When power is applied to the relay solenoid, contact closure is created through movement of the "common" contact of the relay.
Off state impedance is 20KΩ minimum.

Process, 0 - 10VDC, Output 1

Model # 942A - _ **E** _ _ - _ 000

Figure 15 - Process, 0 - 10VDC, Output 1 Wiring.



Process Output
Proportional value determined by the control to balance the sensor input and set point. This value will fall between 0 - 10VDC depending on the thermal characteristics of the system.
Load impedance is 10KΩ minimum.

Process, 4 - 20mA, Output 1

Model # 942A - _ **F** _ _ - _ 000

Figure 16 - Process, 4 - 20mA, Output 1 Wiring.

Process Output
Proportional value determined by the control to balance the sensor input and set point. This value will fall between 4 - 20mA depending on the thermal characteristics of the system.
Load impedance is 600Ω maximum.

Process, 0 - 20mA, Output 1

Model # 942A - _ **G** _ _ - _ 000

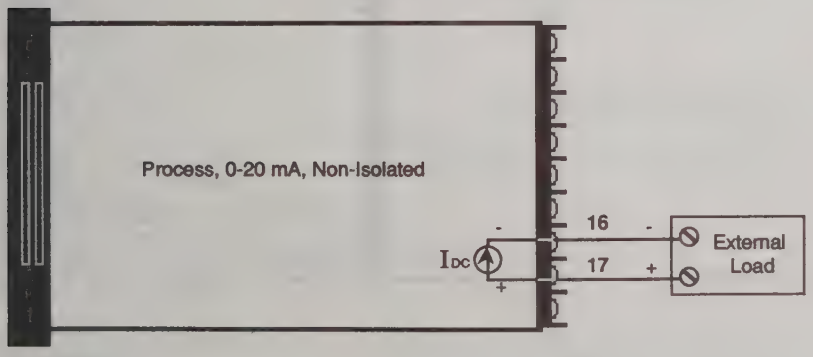


Figure 17 - Process, 0 - 20mA, Output 1 Wiring.

Process Output
Proportional value determined by the control to balance the sensor input and set point. This value will fall between 0 - 20mA depending on the thermal characteristics of the system.
Load impedance is 600Ω maximum.

Process, 0 - 5VDC, Output 1

Model # 942A - _ H _ _ - _ 000

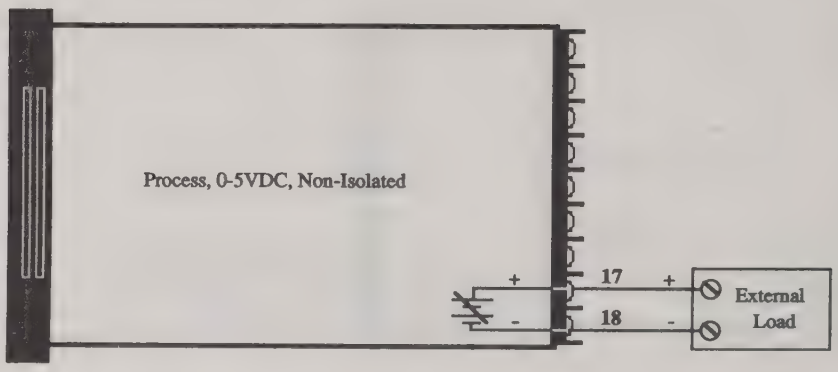


Figure 18 - Process, 0 - 5VDC, Output 1 Wiring.

Process Output
Proportional value determined by the control to balance the sensor input and set point. This value will fall between 0 - 5VDC depending on the thermal characteristics of the system. **Load impedance is 10KΩ minimum.**

Solid State Relay Without Contact Suppression, Output 1

Model # 942A - _ K _ _ - _ 000

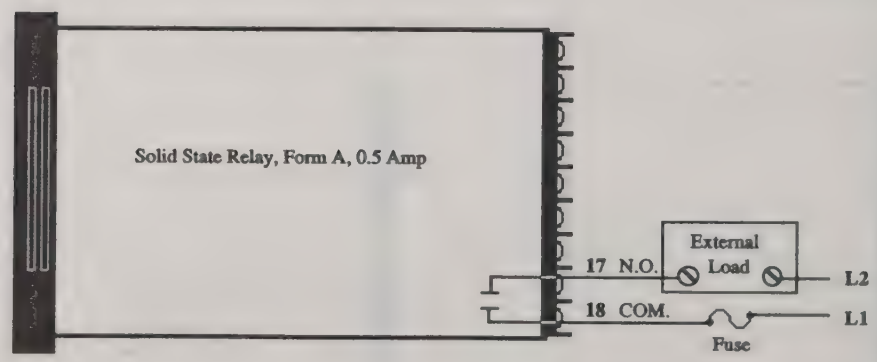


Figure 19 - Solid State Relay Without Contact Suppression, Output 1 Wiring.

Solid State Relay Without Contact Suppression
Watlow's solid state relay changes state at zero volts, which is "zero-cross switching." They are also optically isolated, which means the output circuitry is energized by infrared light striking a photosensitive device. This results in a virtual absence of electrically generated noise, plus output to input electrical isolation. **Off state impedance is nearly infinite and should be used to switch high impedance non-inductive loads.**

Solid State Relay With Contact Suppression, Output 2

Model # 942A - _ _ **B** _ - _ 000

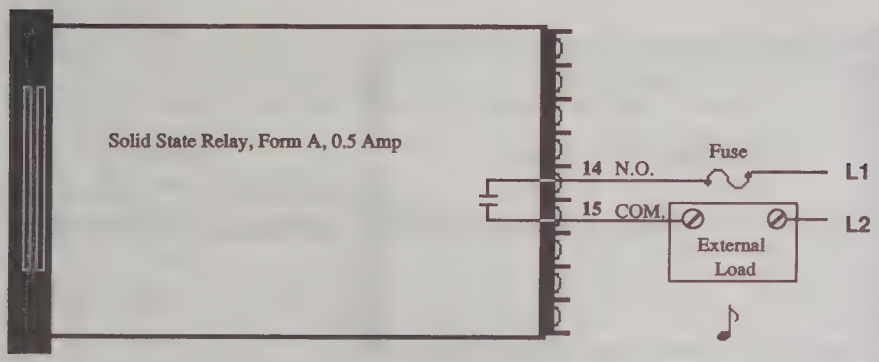


Figure 20 - Solid State Relay With Contact Suppression, Output 2 Wiring.

NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Solid State Relay With Contact Suppression
Watlow's solid state relay changes state at zero volts, which is "zero-cross switching." They are also optically isolated, which means the output circuitry is energized by infrared light striking a photosensitive device. This results in a virtual absence of electrically generated noise, and provides electrical isolation between the input and output. For use in switching mercury relays or small AC loads. **Off state impedance is 20KΩ minimum.**

Switched DC Output (Open Collector), Output 2

Model # 942A - _ _ **C** _ - _ 000

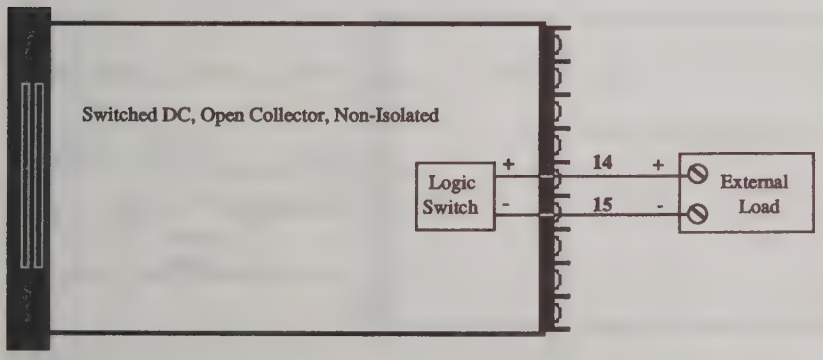


Figure 21 - Switched DC Output (Open Collector), Output 2 Wiring.

Switched DC
Watlow's solid state switch is a low current DC output (open collector) used to switch an external power switching device such as a SSR or an electromechanical relay. The input specifications of the power switching device must match those listed for the S.S. switch output. The power switching device must provide isolation between the S.S. switch output and load power since the S.S. switch output is a non-isolated output. Minimum load resistance is 500Ω. Available current is 9mA minimum and 22mA maximum.

Mechanical Relay, 6 Amp, Form A, Output 2

Model # 942A - _ _ **D** _ - _ 000

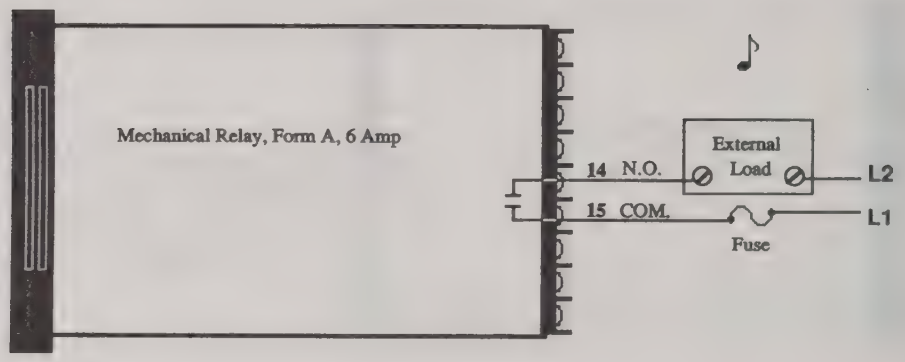


Figure 22 - 6 Amp Mechanical Relay, Output 2 Wiring.

♪ **NOTE:**
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Mechanical Relay
The electromechanical relay is an electrical and mechanical device with moving parts. When power is applied to the relay solenoid, contact closure is created through movement of the "common" contact of the relay. **Off state impedance is 20KΩ minimum.**

Solid State Relay Without Contact Suppression, Output 2

Model # 942A - _ _ **K** _ - _ 000

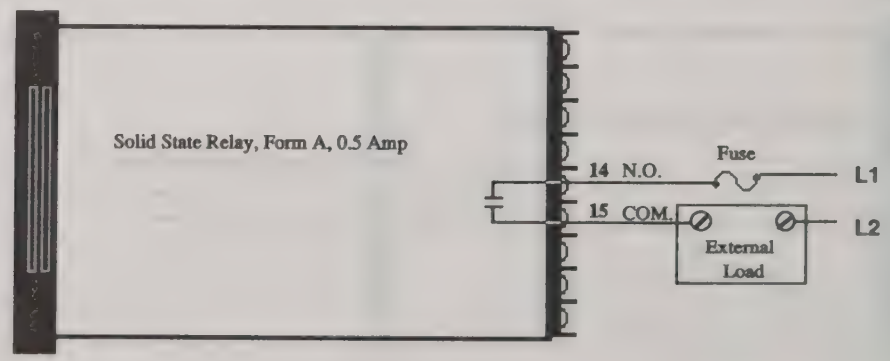


Figure 23 - Solid State Relay Without Contact Suppression, Output 2 Wiring.

Solid State Relay Without Contact Suppression
Watlow's solid state relays change state at zero volts, which is "zero-cross switching." They are also optically isolated, which means the output circuitry is energized by infrared light striking a photosensitive device. This results in virtual absence of electrically generated noise, while providing output to input electrical isolation. **Off state impedance is nearly infinite and should be used to switch high impedance non-inductive loads.**

For more information on alarms, alarm jumper selection and events, see Chapter 6.

Mechanical Relay
The electromechanical relay is an electrical and mechanical device with moving parts. When power is applied to the relay solenoid, contact closure is created through movement of the "common" contact of the relay. **Off state impedance is 20KΩ minimum.**

Mechanical Relay, 6 Amp, Single Form A or B, Auxiliary Output

Model # 942A-___**1**-_000

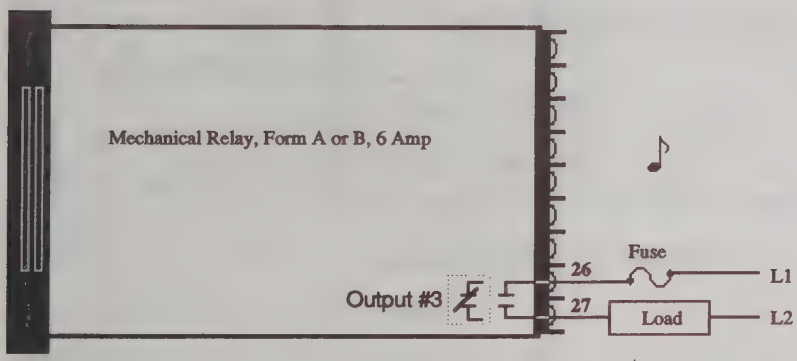


Figure 24 - Auxiliary Option 1 Wiring.

NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Mechanical Relay, 6 Amp, Dual Form A or B, Auxiliary Output

Model # 942A-___**2**-_000

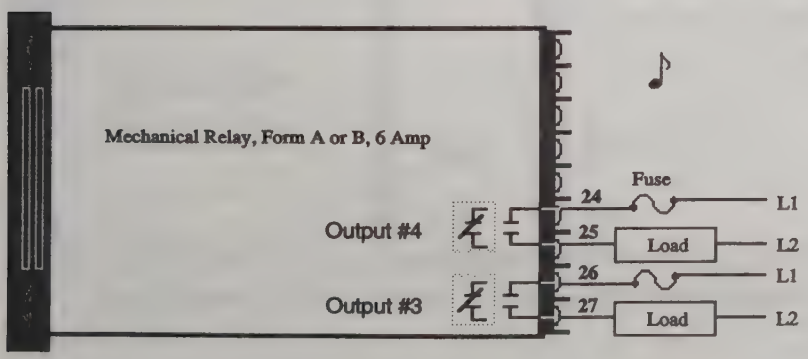


Figure 25 - Auxiliary Option 2 Wiring.

Mechanical Relay
The electromechanical relay is an electrical and mechanical device with moving parts. When power is applied to the relay solenoid, contact closure is created through movement of the "common" contact of the relay.

Mechanical Relay, 6 Amp, Form A or B/0 - 5VDC Retransmit

Model # 942A-___**3**-_000

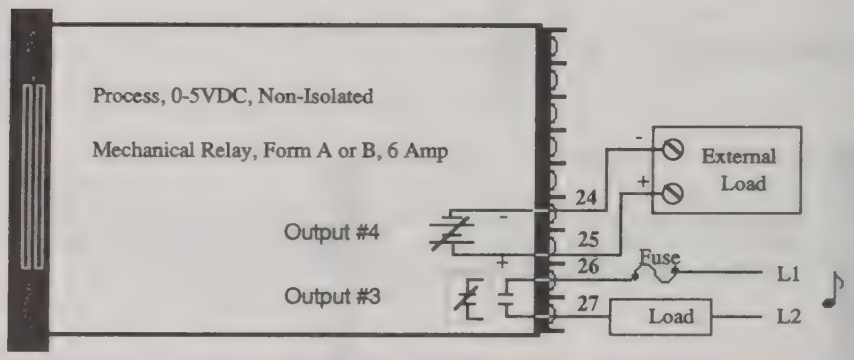


Figure 26 - Auxiliary Option 3 Wiring.

Load impedance 10KΩ mimimum.

NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Mechanical Relay, 6 Amp, Form A or B/4 - 20mA Retransmit

Model # 942A-___**4**-_000

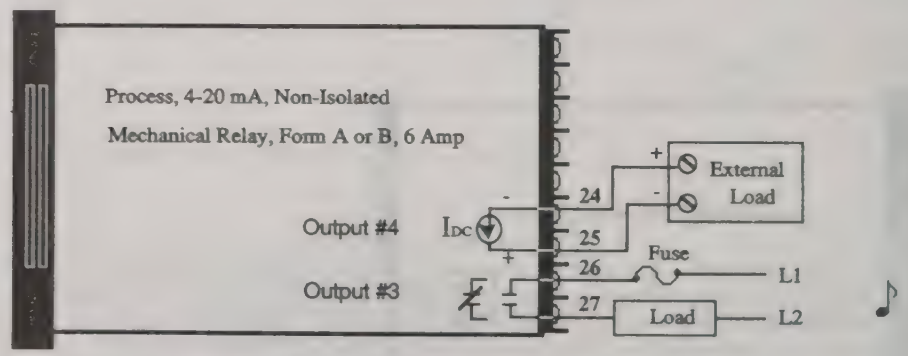


Figure 27 - Auxiliary Option 4 Wiring.

Load impedance 600Ω maximum.

Retransmit Output
When using a retransmit output such as 0 - 5VDC or 4 - 20mA, the rL and rH settings scale the range of the retransmit output.

An example of this is: By setting rL = 0, rH = 1000 and Ot4 = PrOC a process value of 500 will result in a retransmitted signal of 2.5VDC or 12mA.

0 - 5VDC Retransmit, Auxiliary Output

Model # 942A-___**5**-_000

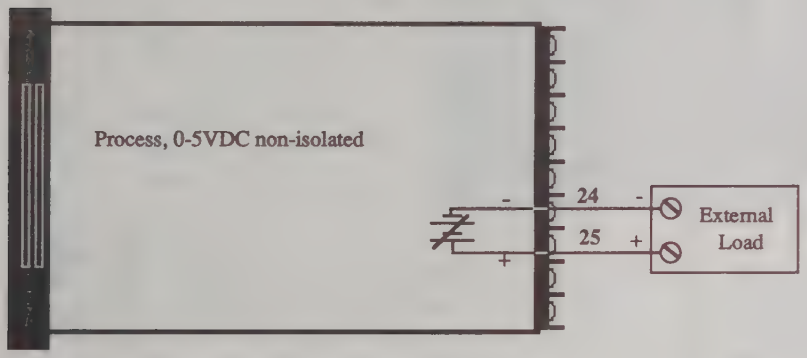


Figure 28 - Auxiliary Option 5 Wiring.

Load impedance 10KΩ mimimum.

4 - 20mA Retransmit, Auxiliary Output

Model # 942A-___**6**-_000

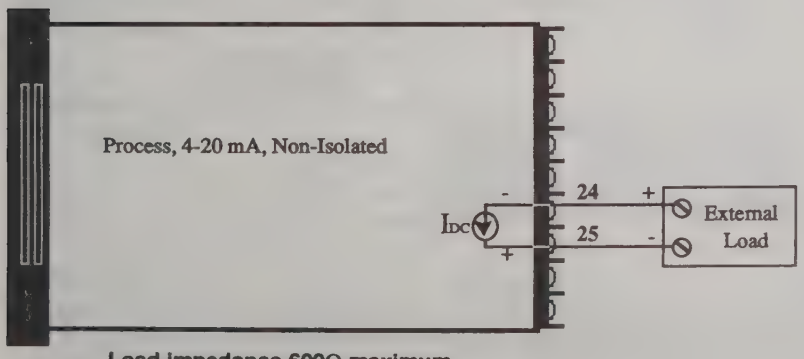


Figure 29 - Auxiliary Option 6 Wiring.

Load impedance 600Ω maximum

Wiring Example

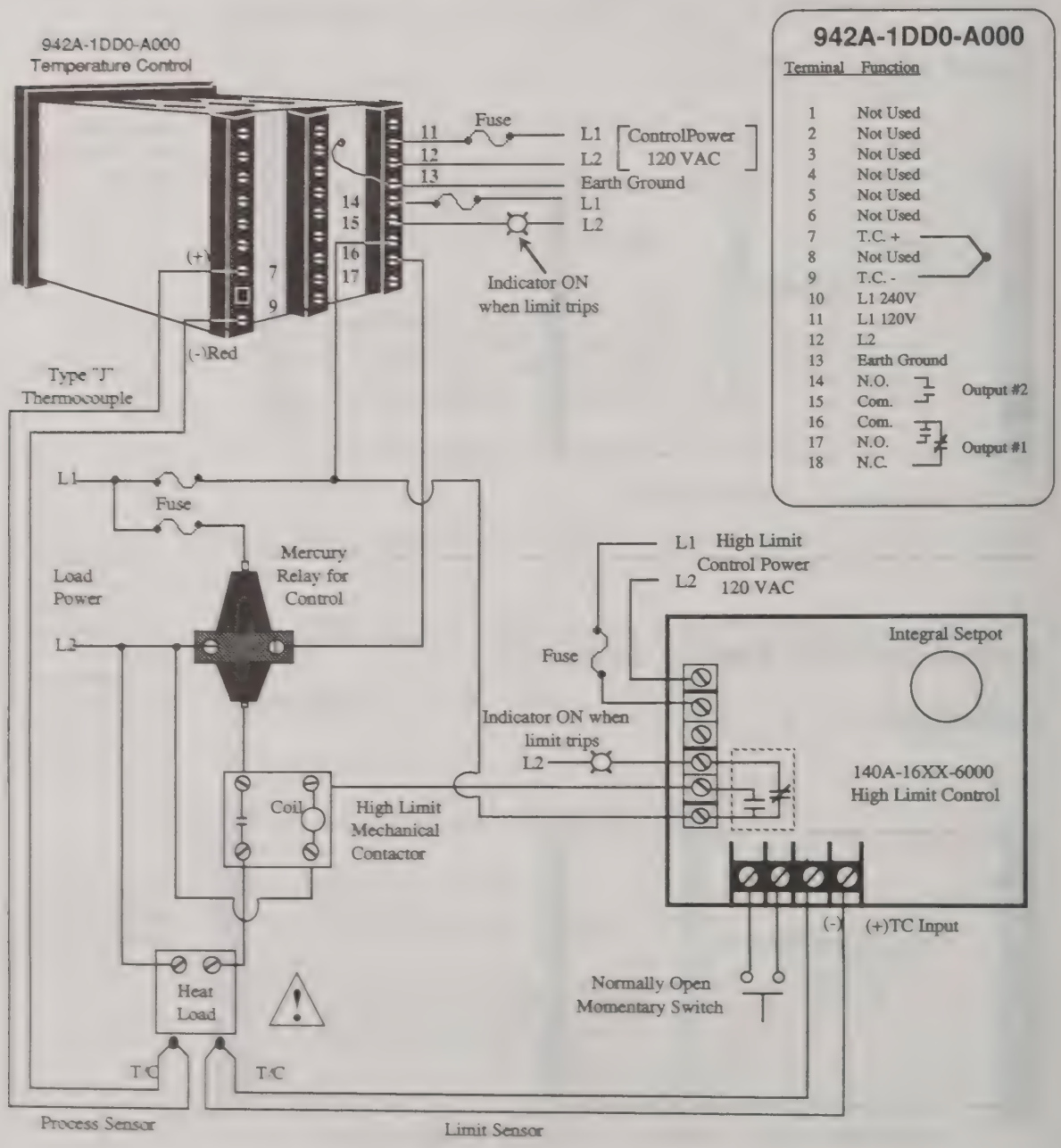
CAUTION:

All wiring and fusing must conform to the National Electric Code NFPA70. Contact your local board for additional information. Failure to observe NEC safety guidelines could result in injury to personnel.

Figure 30 - System Wiring Example

WARNING:

Watlow mercury relays are designed to be used only with resistive loads.



Chapter 3

How to Use the Keys and Displays

After 1 minute with no key activations, the control reverts to the process value in the Upper display and the set point in the Lower display, except when in the RUN menu.

Figure 31 - Series 942 Keys and Displays.

Upper Display
Red, 0.56" (14 mm) high, seven segment, four digit LED display, indicating process variable (such as actual temperature) in addition to parameter values, or an open sensor. When powering up, the Process display will be blank for 8 seconds.

L1 & L2
When lit, these LED's tell you when Output 1 or 2 is energized. L2 only appears if your unit has a #2 output.

L3 & L4
When lit, these LEDs indicate an energized alarm or event condition for Output 3 or 4. Only appears on those units with auxiliary option.

Lower Display
Red 0.56" (14 mm) high, seven segment, four digit LED display, indicating the set point, menu parameters, and alarm or error codes.

UP/DOWN Keys
When pressed simultaneously for 3 seconds, the Setup Menu appears displaying the LOC parameter. At the LOC parameter, continue to press the UP/DOWN keys, and the Calibration Menu will appear.

UP Key
Increases the value of the displayed parameter. A light touch increases the value by one. Hold the key down to increase the value at a rapid rate. New data is self entering in 5 seconds.

DOWN Key
Decreases the value of the displayed parameter. A light touch decreases the value by one. Hold the key down to decrease the value at a rapid rate. New data is self entering in 5 seconds.

HOLD/RUN Key
Pressed once, it clears any latched alarms without altering the HOLD/RUN status. To run or halt a program see Chapter 5 for details.

MODE Key
Steps the control through the Operating menu; also, automatically enters data changes before proceeding to the next parameter.

Front Panel Locking Screw
Secures or releases the control chassis from its case.

HOLD/RUN LED
Lit when the control is RUNning. When blinking, press the HOLD/RUN key again to begin RUNning.

Chapter 4

How To Setup The Series 942

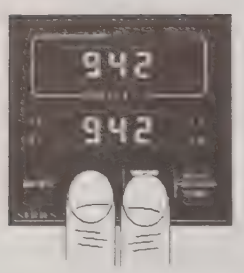


Figure 32 - Entering the Setup Menu.

Setting up the Series 942 is a simple process. First configure the 942's features to your application in the Setup Menu, enter values in the Operating Menu, and program your control. Use the MODE key to move through the menus and the UP/DOWN keys to select data. At this point, enter the Calibration menu, and select US or SI under the **dFL** parameter if necessary. Rate, reset and °F appear with US, and integral, derivative and °C appear with SI. See Appendix III.

Entering the Setup Menu

The Setup Menu displays the parameters that configure the Series 942's features to your application. Enter the Setup Menu by pressing the UP/DOWN keys simultaneously for 3 seconds. The Lower display shows the LOC parameter, and the Upper display shows its current level. All keys are inactive until you release both keys. You can reach the LOC parameter from anywhere except the Run menu. While in the Setup menu, all outputs are OFF.

Use the MODE key to cycle through the menu, and the UP/DOWN keys to select Setup data. You will not see all parameters in this menu, depending on the unit's configuration, model number, and LOC parameter. After stepping through the menu it returns to the control set point parameter under the Operation menu.

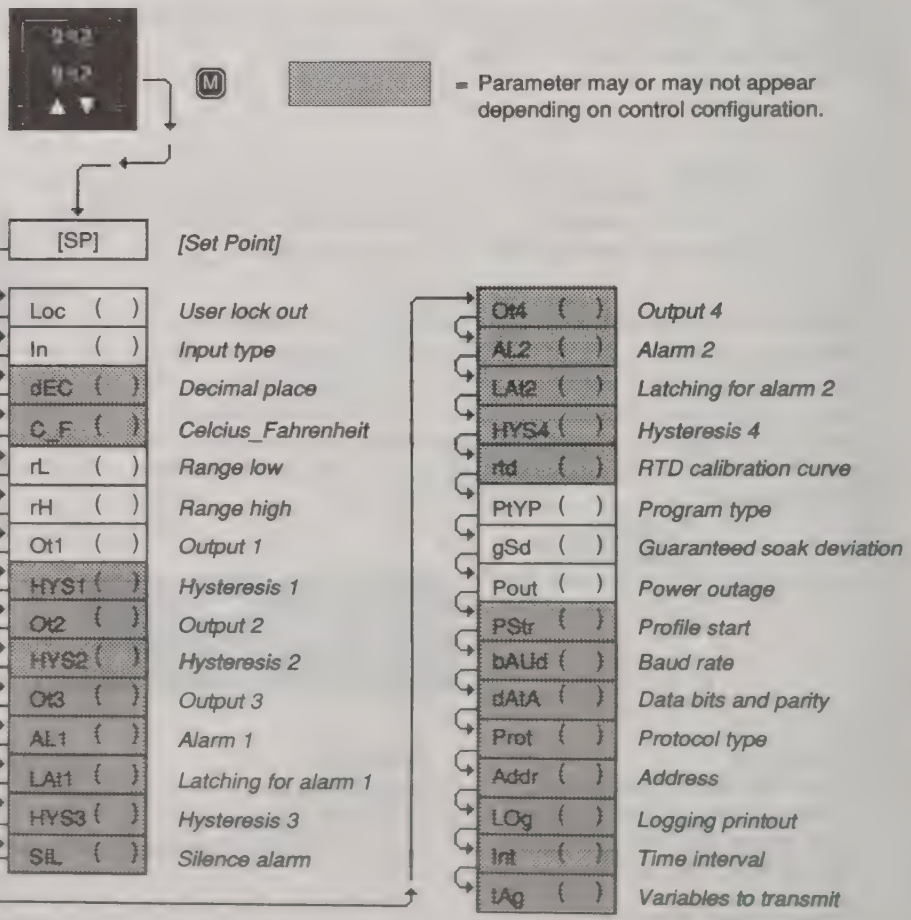


Figure 33 - The Setup Menu.

NOTE:

The rL and rH parameters are used to scale the display for process inputs, and/or will scale the retransmit range for process output. rL and rH also limit the ramge of the set point.

Setup Parameters

When you are at the top of the menu, the Series 942 displays the user level of operation in the Upper display, and the LOC parameter in the Lower display.

When you press the MODE key, the **value** of the next parameter appears in the Upper display, and the parameter appears in the Lower display.

Lock: Selects the level of operator lockout.
Range: 0 - 3 **Default:** 0

LOC

LOC 0: All operating parameters may be viewed or changed.

LOC 1: Locks out the PID parameters. Set point, process value and events are the only visible operating parameters, set point **is** adjustable in this level. A profile can be viewed, changed, run or halted.

LOC 2: Locks out the PID parameters and the Program menu. Set point, process value and events are the only visible operating parameters, set point **is** adjustable. A profile can be run or halted but **not** viewed or changed.

LOC 3: Locks out the entire Operating and Program menus. Set point and process value are the only visible operating parameters, set point **is not** adjustable. A profile can be run or halted but not viewed or changed.

Input: Selects the sensor input type. Only those input types which are compatible with your unit will appear. See the model number information for your type. **Changing this parameter erases all profile steps and defaults them to an End step.**
Range: J, K (appears as H), t, n, c, r, S, b, Pt2, rtd1, rtd.1, 0-5, 420 **Default:** J **or** r

In

Decimal: Selects the location of the decimal point for all process related data. This parameter only appears if the In parameter is 0-5 or 420.
Range: 0, 0.0, 0.00 **Default:** 0

dEC

Celsius _ Fahrenheit: Selects the units of temperature measurement for the control. This parameter only appears if In = T/C or RTD input. **Changing this parameter erases all profile steps and defaults them to an End step.**
Range: C or F **Default:** F

C _ F

Range Low: Selects the low end of the set point range. See the model number and specification information in the Appendix, and Table 1 on Page 26 for sensor range values. Also used to set the low end of the process input and/or the low end of the range for the retransmit output. 0.0VDC and 4mA represent Range Low (rL) for process inputs and outputs. Process inputs and outputs are linearly scaled between rL and rH. **Changing this parameter erases all profile steps and defaults them to an End step.**
Range: Sensor range low to rH **Default:** Low limit of sensor type

rL

Range High: Selects the high end of the set point range. See the model number and specification information in the Appendix, and Table 1 on Page 26 for your sensor range values. Also used to set the high end of the process input and/or the high end of the range for the retransmit output. 5.0VDC and 20mA represent Range High (rH) for process inputs and outputs. Process inputs and outputs are linearly scaled between rL and rH. **Changing this parameter erases all profile steps and defaults them to an End step.**
Range: Sensor range high to rL **Default:** High limit of sensor type

rH

Ot1

Output 1: Selects the output action for the primary output. Action in response to the difference between set point and process variable. Select ht (heat) for reverse acting or select CL (cool) for direct acting.
Range: ht, CL **Default:** ht

HYS1

Hysteresis 1: Selects the switching hysteresis for Output 1 when Pb1 = 0 (ON/OFF). See Page 29 for the Pb1 parameter.

Range:			**Default:** 3°F
	1°F - 999°F	0.1°F - 99.9°F	
	1°C - 540°C	0.1°C - 54.0°C	
	1Unit - 999 Units	0.1 Units - 99.9 Units	

Ot2

Output 2: Selects the output action for the secondary output. Action in response to the difference between set point and process variable. Select ht (heat) for reverse acting or select CL (cool) for direct acting. This parameter only appears if you have a secondary output. If Ot1 = ht: **Range:** CL, no
If Ot1 = CL: **Range:** ht, no **Default:** CL

HYS2

Hysteresis 2: Selects the switching hysteresis for Output 2 when 0 = (ON/OFF) under the Pb 2 parameter. See Page 29 for the Pb2 parameter. This parameter only appears if you have a secondary output.

Range:			**Default:** 3°F
	1°F - 999°F	0.1°F - 99.9°F	
	1°C - 540°C	0.1°C - 54.0°C	
	1Unit - 999 Units	0.1 Units - 99.9 Units	

Ot3

Output 3: Selects Output 3 as an alarm or an event. This parameter only appears if you have at least one auxiliary output.
Range: AL, Ent, no **Default:** AL

AL1

Alarm 1: Determines whether the alarm type for Alarm 1 is process or deviation. A process alarm is set at an absolute temperature to prevent over/under-range. This parameter only appears if you ordered auxiliaries with your unit and Ot3 = AL. See Chapter 6 for more information on alarms.
Range: Pr, dE **Default:** Pr

LAt1

Latching 1: Selects whether Alarm 1 is latching or non-latching. Latching alarms must be cleared before the alarm output will reset. Non-latching automatically resets the alarm output when the condition clears. This parameter only appears if your unit has auxiliary outputs and Ot3 = AL. See Chapter 6.
Range: LAt or nLA **Default:** nLA

HYS3

Hysteresis 3: Selects the switching hysteresis for Output 3 and appears if Ot3 = AL, and your unit has an auxiliary output.

Range:			**Default:** 3°F
	1°F - 999°F	0.1°F - 99.9°F	
	1°C - 540°C	0.1°C - 54.0°C	
	1Unit - 999 Units	0.1 Units - 99.9 Units	

SiL

SIL: Selects alarm silencing (inhibit) for Output 3. This parameter only appears when AL1 = dE, and Ot3 = AL. For more information see Chapter 6.
Range: On or OFF **Default:** OFF

Output 4: Selects Output 4 as an alarm (AL) or event (Ent) if Output 4 is an auxiliary output. Selects Output 4 as retransmit of Process (PrOC) or Set Point (StPt) if Output 4 is a retransmit output. Hardware must also be present. Scaling of the retransmit output is determined by rL and rH.

Ot4

Auxiliary Output:
Range: AL, Ent, no **Default:** AL
Retransmit Output:
Range: PrOC, StPt, no **Default:** PrOC

Alarm 2: Determines whether the alarm type for Output 4 is process or deviation. A process alarm is set at an absolute temperature to prevent over/underrange. This parameter only appears if you ordered auxiliaries with your unit and Ot4 = AL.

AL2

Range: Pr, dE **Default:** Pr

Latching 2: Selects whether Alarm 2 is latching or non-latching. Latching alarms must be cleared before the alarm output will reset. Non-latching automatically resets the alarm output when the condition clears. This parameter only appears if Ot4 = AL, and if your unit has alarms. **Range:** LAt or nLA **Default:** nLA

LAt2

Hysteresis 4: Selects the switching hysteresis for Auxiliary 2 and appears if Ot4 = AL, and your unit has an auxiliary output.

HYS4

Range:			**Default:**
	1°F - 999°F	0.1°F - 99.9°F	3°F
	1°C - 540°C	0.1°C - 54.0°C	
	1Unit - 999 Units	0.1 Units - 99.9 Units	

RTD: Selects the RTD calibration curve for RTD inputs. This parameter appears if In = rtd or rt.d. JIS = 0.003916Ω/Ω°C, DIN = 0.003850Ω/Ω°C.

rtd

Range: din or JIS **Default:** din

Program Type: Selects the program type as time based (ti) or ramp rate (rAtE) in degrees per minute. **Changing this parameter erases all profile steps and defaults them to an End step.**

PtYP

Range: ti (time based) or rAtE (ramp rate) **Default:** ti

Guaranteed Soak Deviation: Guarantees the actual temperature is being controlled within a window around the set point. If this deviation is exceeded, the time clock stops and the lower display alternately flashes gSd and the current parameter until the process variable returns within the window. See Chapter 5 for more information on the guaranteed soak deviation parameter.

gSd

Example: A guaranteed soak deviation of 3 equals a ± 3° deviation about the current set point.
0 = Guaranteed soak deviation **not** active. >0 = Active guaranteed soak

Range:			**Default:**
	0°F - 99°F	0.0°F - 9.9°F	0°
	0°C - 55°C	0.0°C - 5.5°C	
	0 - 99 Units	0.0 - 9.9 Units	

Power Outage: Selects the profile status upon power restoration following a power loss. By selecting continue (Cont), your profile continues running from where it was interrupted. HOLd maintains the last set point prior to power loss. Abort (Abrt) quits running the profile, displays OFF in the lower display, and turns off all outputs. When Abrt or HOld are selected, the lower display alternately flashes Pout and the current parameter. rSET (Reset) causes a start from the beginning of your profile. Press the HOLD/RUN key to clear.

Pout

Range: Cont (Continue), HOLd, Abrt (Abort), rSET (Reset) **Default:** Cont

PStr

Profile Start: Selects whether the profile starts at the current set point value or the current process value.
Range: Proc or StPt **Range:** StPt

bAud

Baud: Represents the current baud rate for serial communications. This parameter appears if your Series 942 has communications.
Range: 300, 600, 1200, 2400, 4800, 9600 **Default:** 1200

dAtA

Data: Allows the user to select the data bits and parity for communication. This parameter appears if your Series 942 has communications.
Range: 7 o = 7 data bits and odd parity **Default:** 7 o
7 E = 7 data bits and even parity
8 n = 8 Data bits and no parity

Prot

Protocol: Selects the communication protocol. This parameter appears if your Series 942 has communications.
FULL = ANSI X3.28 2.2 - A.3 On = XON - XOFF
Range: FULL or On **Default:** FULL

Addr

Address: Selects the address for this unit if Prot = FULL. This parameter appears if your Series 942 has communications.
Range: 0 to 31 **Default:** 0

LOg

Log: Selects the data logging function for a printout of the data. This parameter appears if your Series 942 has communications, and Prot = On.
Range: On or OFF **Default:** OFF

Int

Interval: Selects the time interval for the logging function This parameter appears if your Series 942 has communications, Prot = On, and Log = On.
Range: 0.0 to 60.0 minutes Default: 0.0

tAg

Tag: Selects what variables are to be transmitted out during the data logging function. This parameter appears if your Series 942 has communications, Prot = On, and Log = On.
P = Process S = Set Point A = Auxiliary Status
Range: PSA, PS-, P-A, P--, -SA, -S-, --A, --- **Default:** ---

Table 1- Input Ranges

Input Type	Sensor Range Low	Sensor Range High
J	32°F/0°C	1382°F/750°C
K (appears as H)	-328°F/-200°C	2282°F/1250°C
t	-328°F/-200°C	662°F/350°C
n	32°F/0°C	2282°F/1250°C
Pt2	32°F/0°C	2543°F/1395°C
c	797°F/425°C	4200°F/2315°C
r	32°F/0°C	2642°F/1450°C
S	32°F/0°C	2642°F/1450°C
b	*32°F/0°C	3092°F/1700°C
rtd (1°)	-328°F/-200°C	1112°F/600°C
rt.d (0.1°)	-99.9°F/-99.9°C	392.0°F/200.0°C
0-5 (VDC)	-5.00/-50.0/-500	35.00/350.0/3500
420 (mA)	-5.00/-50.0/-500	35.00/350.0/3500

♪ **NOTE:**

*** b t/c: Useable range is suggested to be 1598 to 3092°F or 870 to 1700°C. Range is at 32° to allow using at low temperatures without range low sensor errors.**

Table 2 -
Setup Menu Parametersand Descriptions.

Setup Parameters	Value	Range	Factory Default
LOC		0 to 3	0
In		J, K (appears as H), t, n, c, r, S, b, Pt2, rtd1, rtd.1, 0-5, 420 Dependent on model number.	J or r
dEC		0, 0.0, or 0.00 Dependent on input type.	0
C _ F		C or F Will not appear if In = 0-5 or 420.	F
rL		rL to rH	Input selection dependent.
rH		rH to rL	Input selection dependent.
Ot1		ht or CL	ht
HYS1		1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
Ot2		ht, CL or no	CL
HYS2		1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
Ot3		AL, Ent or no	AL
AL1		Pr or dE	Pr
LAt 1		LAt or nLA Dependent on AL 1 = Pr or dE.	nLA
HYS3		1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
SIL		On or OFF	OFF
Ot4		AL, Ent, no, PrOC or StPt	AL or PrOC
AL 2		Pr or dE	Pr
LAt 2		LAt or nLA	nLA
HYS4		1°F - 999°F, 1°C - 540°C, 1U - 999U 0.1°F - 99.9°F, 0.1°C - 54.0°C, 0.1U - 99.9U	3°F
rtd		JIS or din	din
PtYP		ti or rAtE	ti
gSd		0 - 99°F, 0 - 55°C, 0 - 99U 0.0 - 9.9°F, 0.0 - 5.5°C, 0.0U - 9.9U	0
POUt		Cont, HOLd, Abrt or rSET	Cont
PStr		Proc or StPt	StPt
bAUd		300, 600, 1200, 2400, 4800, 9600	1200
dAtA		7 o = Odd parity, 7 E = Even parity 8 n = 8 data bits and no parity	7 o
Prot		FULL or On	FULL
Addr		0 to 31	0
Log		On or OFF	OFF
Int		0.0 to 60.0 minutes	0.0
tag		PSA, PS-, P-A, P--, -SA, -S-, --A, --- P = Process, S = Set point A = Auxiliary Status	---

Operation Menu

In the Operation menu, the 942 operates as a digital set point control. Select a set point and the 942 attains that value on a non-linear ramp. If your unit has auxiliary outputs programmed as events, they can be selected as ON or OFF. All outputs are turned OFF when set point is set to OFF.

NOTE:
The Upper display always returns to the process value after 1 minute without key strokes.

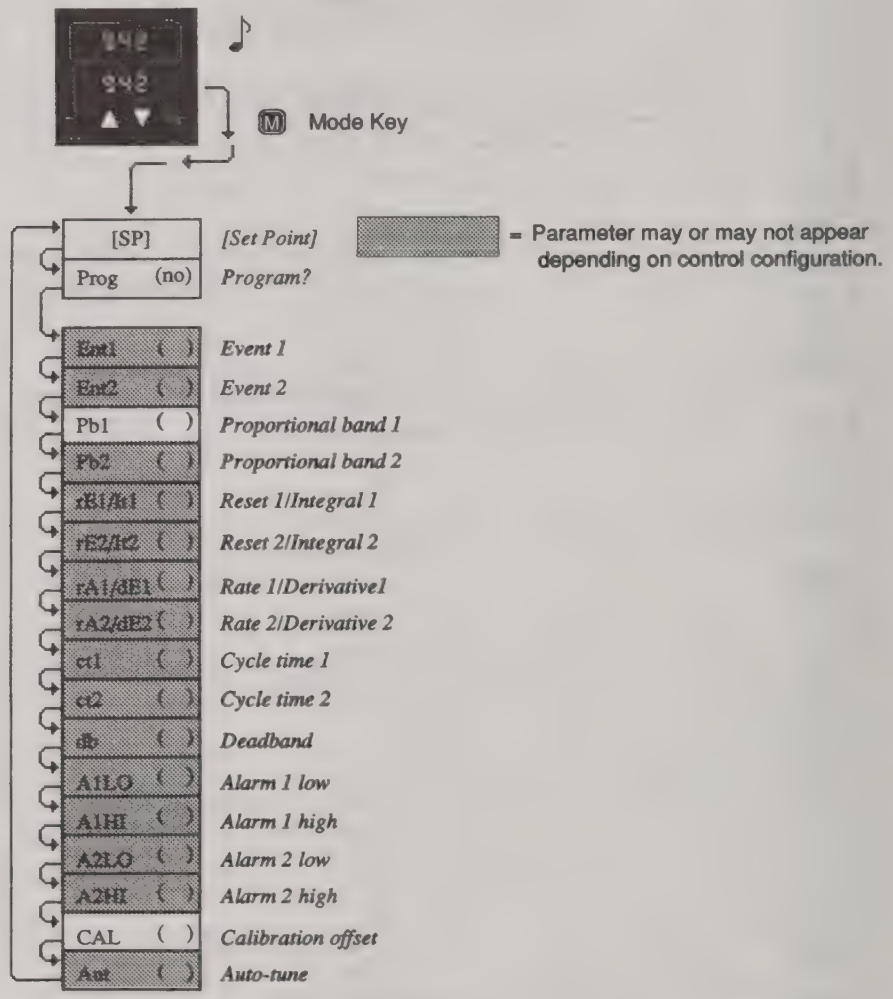

M Mode Key
[SP] [Set Point]
Prog (no) Program?
= Parameter may or may not appear depending on control configuration.
Ent1 ( ) Event 1
Ent2 ( ) Event 2
Pb1 ( ) Proportional band 1
Pb2 ( ) Proportional band 2
rE1/It1 ( ) Reset 1/Integral 1
rE2/It2 ( ) Reset 2/Integral 2
rA1/dE1 ( ) Rate 1/Derivative1
rA2/dE2 ( ) Rate 2/Derivative 2
ct1 ( ) Cycle time 1
ct2 ( ) Cycle time 2
db ( ) Deadband
A1LO ( ) Alarm 1 low
A1HI ( ) Alarm 1 high
A2LO ( ) Alarm 2 low
A2HI ( ) Alarm 2 high
CAL ( ) Calibration offset
Aut ( ) Auto-tune

Figure 34 -
The Operation Menu.

Operation Parameters

[SP]

Set Point: Sets the operating set point for the control outputs. "SP" does not appear, the control set point **value** will. Decrementing the set point below rL displays OFF in the lower display. This disables all outputs except deviation alarm outputs, which remain energized.
Range: OFF/ rL to rH **Default:** Dependent on input range

Prog (no)

Program: Select whether you want to enter the Program menu or enter the Operation menu. By selecting no, you continue to the Operation menu.
Range: YES or no **Default:** no

Ent1

Ent1: Select whether Event 1 (Output 3) is ON or OFF. When a profile is complete or has been put on hold, it holds at its previous state. Only appears if Ot3 = Ent, and your unit has auxiliary outputs. For more information on events see Chapter 6. **Range:** On or OFF **Default:** OFF

Ent2

Ent2: Select whether Event 2 (Output 4) is ON or OFF. When a profile is complete or has been put on hold, it will hold at its previous state. This parameter only appears if Ot4 = Ent, and your unit has auxiliary outputs. For more information on events see Chapter 6. **Range:** On or OFF **Default:** OFF

Pb1

Proportional Band 1: A proportional band expressed in degrees or process units, or % of span, within which a controller proportioning function is active for Output 1. When Pb1 = 0, it functions as an ON/OFF control. The switching differential is then determined by the HYS1 parameter. If dFL = US: **Range:** 0 to 999°F/0 to 555°C/0 to 999 Units; 0.0 to 99.9°F/0.0 to 55.5°C/0.0 to 99.9 Units **Default:** 25°F/2.5°F
If dFL = SI: **Range:** 0 to 999.9% of span **Default:** 3.0%
Span is defined as the operating range of the input sensor or rL to rH if the input type is 0-5 or 420.

Pb2

Proportional Band 2: A proportional band expressed in degrees or process units, or in % of span, within which a controller proportioning function is active for Output 2. When Pb2 = 0, it functions as an ON/OFF control. The switching differential is determined by the HYS2 parameter. This parameter will not appear if your unit does not have a secondary output or Ot2 = no. If dFL = US: **Range:** 0 to 999°F/0 to 555°C/0 to 999 Units; 0.0 to 99.9°F/0.0 to 55.5°C/0.0 to 99.9 Units **Default:** 0°
If dFL = SI: **Range:** 0 to 999.9% of span **Default:** 0.0%

rE1/It1

Reset /Integral1: A reset (integral) control action for Output 1 automatically eliminating offset, or "droop," between set point and actual process temperature in a pro-portional control. Will not appear if your unit does not have a secondary output, or Pb1 = 0. **Reset Range:** 0.00 to 9.99 repeats/minute **Integral Range:** 0 and 00.1 to 99.9 minutes/repeat **Default:** 0.00

rE2/It2

Reset /Integral 2: A reset (integral) control action for Output 2 that automatically eliminates offset, or "droop," between set point and actual process temperature in a proportional control. This parameter will not appear if your unit does not have a secondary output, or Pb 2 = 0, or if Ot 2 = no. **Reset Range:** 0.00 to 9.99 repeats/minute **Integral Range:** 0 and 00.1 to 99.9 minutes/repeat **Default:** 0.00

rA1/dE1

Rate /Derivative 1: The rate (derivative) function for Output 1 of the Series 942. The rate is determined by how fast the error is changing. This parameter will not appear if Pb 1 = 0. **Range:** 0.00 to 9.99 minutes **Default:** 0.00

rA2/dE2

Rate/Derivative 2: Rate (derivative) function for Output 2. Rate is determined by how fast the error is changing. Does not appear if your unit does not have a secondary output, Pb 2 = 0, or Ot 2 = no. **Range:** 0.00 to 9.99 min. **Default:** 0.00

Ct1

Cycle Time 1: Expressed in seconds, time for a controller to complete one ON/OFF cycle for Output 1. Time between successive turn ons. This parameter will not appear if Pb 1 = 0, or Output 1 is a process output.
Range: 1 to 60 seconds **Default:** 5

Ct2

Cycle Time 2: Expressed in seconds, time for a controller to complete one ON/OFF cycle for Output 2. Time between successive turn ons. This parameter will not appear if your unit does not have a secondary output, Pb 2 = 0, or Ot 2 = no.
Range: 1 to 60 seconds **Default:** 5

db

Dead Band: The area between Output 1 and 2 where no heating or cooling takes place in a heat/cool proportional control. This parameter only appears if your unit is set up as a ht/CL or CL/ht unit. **Range:** ±0 to 99°F/0 to 55°C/0 to 99 Units; or ±0.0 to 9.9°F/0.0 to 5.5°C/0.0 to 9.9Units **Default:** 0

A1LO

Alarm 1 Low: Represents the low process alarm or low deviation alarm for Alarm 1. This parameter only appears if you have an auxiliary output and Ot3 = AL. See the model number. If AL 1 = Pr: **Range:** rL to A1HI **Default:** rL
If AL 1 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

A1HI

Alarm 1 High: This parameter represents the high process alarm or high deviation alarm for Alarm 1. This parameter appears if your unit has an auxiliary output and Ot3 = AL. See the model number. If AL 1 = Pr: **Range:** A1LO to rH **Default:** rH
AL 1 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

A2LO

Alarm 2 Low: Represents the low process alarm or low deviation alarm for Alarm 2. Appears if your unit has an auxiliary output and Ot4 = AL. See the model number. If AL 2 = Pr: **Range:** rL to A2HI **Default:** rL
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F.

A2HI

Alarm 2 High: Represents the high process alarm or high deviation alarm for Alarm 2. Appears if your unit has an auxiliary output and Ot4 = AL. See the model number. If AL 2 = Pr: **Range:** A2LO to rH **Default:** rh
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F

CAL

Calibration Offset: Adds or subtracts degrees from the input signal. **Range:** -99°F to 99°F/-55°C to 55°C/-99 Units to 99 Units; or -99.9°F to 99.9°F/-55.5°C to 55.5°C **Default:** 0

AUt

Auto-Tune: This parameter initiates auto-tune for Output 1 in the heating mode only. This parameter appears if Ot1 = ht. For more information on Tuning see Chapter 6. **Range:** 0 = off, 1 = slow, 2 = medium, 3 = fast **Default:** 0

Table 3 -
Operation Menu Parameters and Descriptions.

Operation Parameters	Value	Range	Factory Default
SP		OFF/rL to rH	75°F
Prog		YES or no	no
Ent1		On or OFF	OFF
Ent2		On or OFF	OFF
Pb1		If dFL = US: 0 - 999°F/0 - 555°C/0 - 999 Units 0 - 99.9°F/0 - 55.5°C/0 - 99.9 Units If dFL = SI: 0 to 999.9% 0 = ON/OFF control. HYS1 = switch. diff.	25°F 3.0%
Pb2		Same as Pb1. Will not appear if Ot 2 = no.	0°
rE1/It1		Reset: 0.00 to 9.99 repeats/min. Integral: 0 and 00.1 to 99.9 min./repeat 0.00 = no reset. Will not appear if Pb1 = 0.	0.00 repeats/min.
rE2/It2		Same as rE1. Will not appear if Pb2 = 0.	0.00 repeats/min.
rA1/dE1		0.00 to 9.99 min. 0.00 = No Rate. Will not appear if Pb1 = 0	0.00 min.
rA2/dE2		Same as rA1. Will not appear if Pb2 = 0.	0.00 min.
Ct1		1 to 60 seconds Won't appear if Pb1 = 0, or output 1 is 4-20	5 seconds
Ct2		1 to 60 seconds Will not appear if Pb2 = 0 or Ot2 = no.	5 seconds
db		± 0 - 99°F/± 0 - 55°C/0 - 99 Units. ± 0.0 - 9.9°F/0.0 - 5.5°C/0.0 - 9.9 Units Appears if ht/CL or CL/ht.	0
A1LO - Deviation dE Process Pr		-999° to 0° rL to A1HI Appears if auxiliary output and Ot3 = AL.	-999° rL
A1HI - Deviation dE Process Pr		0° to 999° A1LO to rH Appears if auxiliary output and Ot3 = AL.	999° rH
A2LO- Deviation dE Process Pr		-999° to 0° rL to A2HI Appears if auxiliary output and Ot4 = AL.	-999 rL
A2HI- Deviation dE Process Pr		0° to 999° A2LO to rH Appears if auxiliary output and Ot4 = AL.	999° rH
CAL		± 99°F/± 55°C/± 99 Units	0
AUt		0 to 3	0

Chapter 5

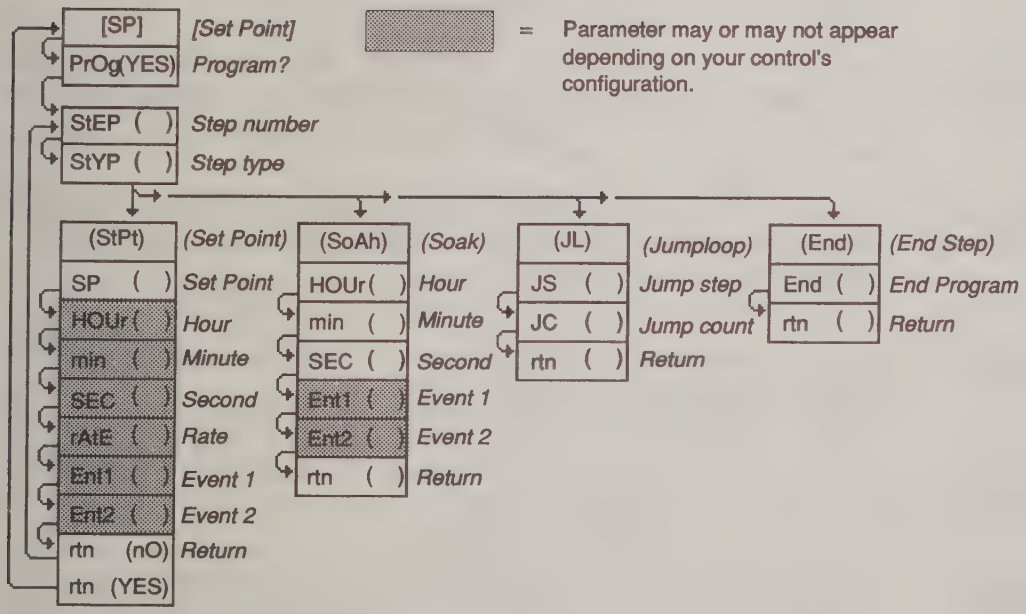
How to Program & Run the Series 942

We begin this chapter by introducing the Program menu. Each parameter is clearly defined. A description of a few Series 942 features follows, along with a sample profile to experiment with programming the Series 942. You will quickly grasp the necessary terms and concepts by entering and observing your profiles. Enter your profile values in the Master Step Chart at the end of the chapter.

PROGRAM Menu

Create your profiles here in the Program menu. Your profile can have up to 24 steps. Choose one step type per step.

Figure 35 -
The Program Menu.


[SP] [Set Point]
PrOg(YES) Program?
= Parameter may or may not appear depending on your control's configuration.
StEP ( ) Step number
StYP ( ) Step type
(StPt) (Set Point)
SP ( ) Set Point
HOUr ( ) Hour
min ( ) Minute
SEC ( ) Second
rAtE ( ) Rate
Ent1 ( ) Event 1
Ent2 ( ) Event 2
rtn (nO) Return
rtn (YES)
(SoAh) (Soak)
HOUr ( ) Hour
min ( ) Minute
SEC ( ) Second
Ent1 ( ) Event 1
Ent2 ( ) Event 2
rtn ( ) Return
(JL) (Jumploop)
JS ( ) Jump step
JC ( ) Jump count
rtn ( ) Return
(End) (End Step)
End ( ) End Program
rtn ( ) Return

Program Parameters

Prog (YES)

Program: Select whether you want to enter the Operation or the Program menu. Selecting YES continues into the Program menu.
Range: YES or no **Default:** no

StEP

Step: Represents the current step of the profile to be edited or viewed. When selecting Step 1, you will not see the JL step type.
Range: 1 to 24 **Default:** 1 then automatic increment

StYP

Step Type: Choose from four different step types.
Range: StPt, SoAh, JL or End **Default:** End

(StPt)

Set Point Step (StPt) : The following parameters are associated with the set point step.

SP

Set Point: Represents the temperature the system tries to achieve. This is done linearly, producing a ramp from a beginning set point to an end set point.
Range: rL to rH **Default:** 75°F/24°C or rL value if rL ≥ 75°F/24°C or if rH≤ 75°F/24°C

HOUr

Hour: The number of hours, in combination with the Min and SEC parameters, equaling total step time to achieve the temperature under the StPt step type. This parameter only appears if PtYP = ti.
Range: 0 to 23 **Default:** 0

Min

Minutes: The number of minutes, in combination with the HOUr and SEC parameters, equaling total step time to achieve the temperature under the StPt step type. This parameter only appears if PtYP = ti.
Range: 0 to 59 **Default:** 0

SEC

Seconds: The number of seconds, in combination with the HOUr and Min parameters, equaling total step time to achieve the temperature under the StPt step type. This parameter only appears if PtYP = ti.
Range: 0 to 59 **Default:** 0

rAte

Rate: Represents the rate at which the set point changes in degrees per minute. This parameter only appears if PtYP = rAte.
Range: 0 to 360°F/0 to 200°C or 0.0 to 360.0°F/0.0 to 200.0°C **Default:** 0.0

Ent1

Event 1: Selects whether Event 1 is on or off. This parameter only appears if Ot3 = Ent.
Range: On or OFF **Default:** OFF

Ent2

Event 2: Selects whether Event 2 is on or off. This parameter only appears if Ot4 = Ent.
Range: On or OFF **Default:** OFF

rtn

Return: Select no and you return to the StEP parameter to continue programming. By selecting YES, you exit the program menu and return to the control set point.
Range: YES or no **Default:** no

Soak (SoAh) : The following parameters are associated with the soak step. (SoAh)

Hour: The number of hours, in combination with the Min and SEC parameters, equaling total step time to achieve the temperature under the SoAh step type. This parameter only appears if PtYP = ti. HOUr
Range: 0 to 23 **Default:** 0

Minutes: The number of minutes, in combination with the HOUr and SEC parameters, equaling total step time to achieve the temperature under the SoAh step type. This parameter only appears if PtYP = ti. Min
Range: 0 to 59 **Default:** 0

Seconds: The number of seconds, in combination with the HOUr and Min parameters, equaling total step time to achieve the temperature under the SoAh step type. This parameter only appears if PtYP = ti. SEC
Range: 0 to 59 **Default:** 0

Event 1: Selects whether Event 1 is on or off. Only appears if Ot3 = Ent. Ent1
Range: On or OFF **Default:** OFF

Event 2: Selects whether Event 2 is on or off. Only appears if Ot4 = Ent. Ent2
Range: On or OFF **Default:** OFF

Return: Select no and you return to the StEP parameter to continue programming the 942. By selecting YES, you exit the program menu and return to the control set point. rtn
Range: YES or no **Default:** no

Jumploop Step (JL) : The following parameters are associated with the jumploop step. When StEP = 1, JL will not appear. (JL)

Jump Step: The Series 942 jumps backwards to any step in your file. JS
Range: 1 to 23 **Default:** 1

Jump Count: The number of times the Series 942 jumps to the step specified by the JS (jump step) parameter. 0 = infinite number of jumps. JC
Range: 0 to 100 **Default:** 0

Return: Select no and you return to the StEP parameter to continue programming the Series 942. By selecting YES, you exit the program menu and return to the control set point. **Range:** YES or no **Default:** no rtn

End Step (End) : The following parameters are associated with the end step. (End)

End: When HOLd is selected, the control and auxiliary outputs are enabled and maintain the same state as in the last set point and/or soak step before the End step was encountered. When selected as OFF, the control and auxiliary outputs (except for deviation alarms) are de-energized and OFF is shown in the lower display. When selected as OFFA, the control outputs are de-energized and OFF is shown in the lower display. Deviation alarms are inactive (relay energized) and process alarms are active (relay energized in non-alarm conditions). End
Range: HOLd or OFF **Default:** HOLd

Return: Select no and you return to the StEP parameter to continue programming the 942. By selecting YES, you exit the program menu and return to the control set point. **Range:** YES or no **Default:** no rtn

Running a Series 942 Profile

You can run your Series 942 profile from anywhere except the Setup menu. Press the HOLD/RUN key. The RUN LED begins flashing, and the lower display flashes and asks what StP (step) to begin on. Use the UP/DOWN key to enter the step and press the HOLD/RUN key once again, your profile begins, and the RUN LED is lit. If the HOLD/RUN key is not pressed twice within 1 minute, the RUN function will abort. **While the profile is RUNning, you can only view the RUN menu.** Press the MODE key to advance you through the RUN menu. For more information on Pout (power outages) see Page 25.

Resume a Profile

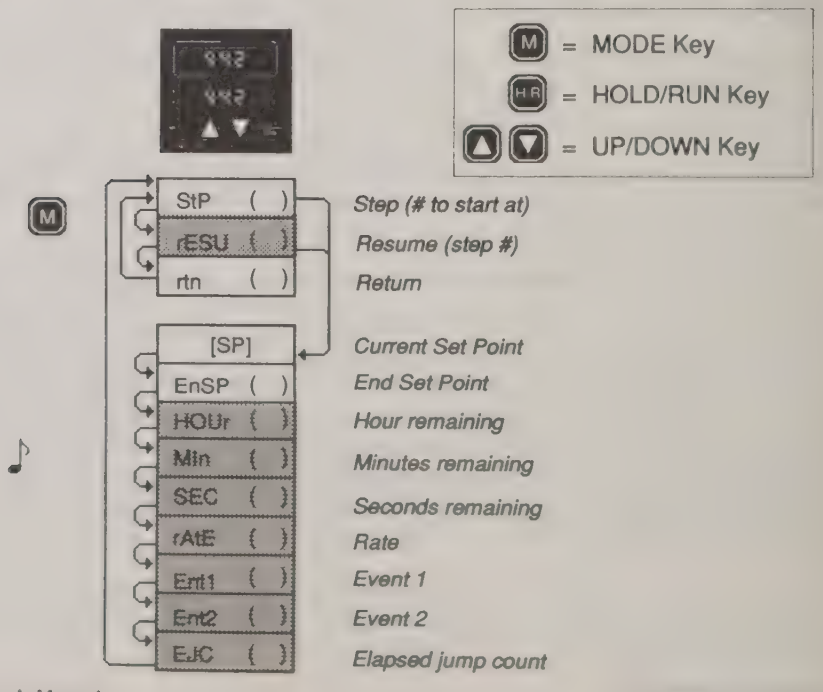
To resume a halted profile, press the HOLD/RUN key once. Press the MODE key to advance to the rESU parameter, and press the HOLD/RUN key again, the profile resumes, and the RUN LED is lit. You can only resume at the **exact** step you left off on. If you halt a running profile and make changes, you **cannot** resume running. The rESU parameter only appears when a running profile is halted.

To **Run** your profile... Press the HR key twice.

To **Stop** a running profile... Press the HR key once.

To **Resume** a halted profile... Press the HR key, press the M key to advance to the rESU parameter, and press the HR key.

Figure 36 - The Run Menu.



NOTE:

Shaded parameters may not appear on your control. These parameters are dependent on how your control is configured.

Chart 1 - Master Step Chart Make photocopies, keep original clean.

Step #	√	Step Type	Values		Time			On Events OFF	
	☐	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
					rAtE				
	☐	SoAh			HOUr	Min	SEC	Ent1	Ent2
	☐	JL	JS	JC					
	☐	End	OFF		OFFA	HOLd			

Step #	√	Step Type	Values		Time			On Events OFF	
	☐	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
					rAtE				
	☐	SoAh			HOUr	Min	SEC	Ent1	Ent2
	☐	JL	JS	JC					
	☐	End	OFF		OFFA	HOLd			

Step #	√	Step Type	Values		Time			On Events OFF	
	☐	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
					rAtE				
	☐	SoAh			HOUr	Min	SEC	Ent1	Ent2
	☐	JL	JS	JC					
	☐	End	OFF		OFFA	HOLd			

Step #	√	Step Type	Values		Time			On Events OFF	
	☐	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
					rAtE				
	☐	SoAh			HOUr	Min	SEC	Ent1	Ent2
	☐	JL	JS	JC					
	☐	End	OFF		OFFA	HOLd			

Step #	√	Step Type	Values		Time			On Events OFF	
	☐	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
					rAtE				
	☐	SoAh			HOUr	Min	SEC	Ent1	Ent2
	☐	JL	JS	JC					
	☐	End	OFF		OFFA	HOLd			

Step #	√	Step Type	Values		Time			On Events OFF	
	☐	StPt	SP		HOUr	Min	SEC	Ent1	Ent2
					rAtE				
	☐	SoAh			HOUr	Min	SEC	Ent1	Ent2
	☐	JL	JS	JC					
	☐	End	OFF		OFFA	HOLd			

Event Outputs

One of the features of the Series 942 is its capability for two event outputs. An "event output" is simply a pre-programmed ON/OFF event per profile step. The event may turn any number of peripheral devices ON or OFF to assist you in controlling your process, system or environment.

For instance, in an environmental chamber, you might wish to circulate air at a given time in your profile for one or more steps. You might want to turn lights on or off, or signals, or lock out your humidifier, or you could activate a video recorder.

Ent1 and Ent2 are not visible under the Operation menu unless your unit has auxiliary outputs and you Setup Ot3 and Ot4 as events.

To select auxiliary outputs as events, enter the Setup menu by pressing the UP/ DOWN keys simultaneously for 3 seconds. The LOC parameter appears. Press the MODE key until you reach the Ot3 parameter. The default for Ot3 is AL (alarms). Change the value to Ent (event) if it hasn't already been done. Press the MODE key to continue on to the Ot4 parameter. Do the same for this parameter also. Continue pressing the MODE key to exit the Setup menu.

If you return to the Operation menu, Ent1 and Ent2 are visible, and can be turned ON or OFF from here. Ent1 and Ent2 can also be viewed under the StPt (Set Point) and SoAh (Soak) parameters in the Program menu.

These event outputs are mechanical relays rated at 6 amps up to 240VAC.

Guaranteed Soak Deviation

The Series 942 Guaranteed Soak Deviation (gSd) feature insures that the actual temperature tracks a programmed profile within a window around set point. See the example on the next page. If the deviation is exceeded, the time clock stops and the lower display alternately flashes gSd and the current parameter until the process variable returns within the window. Programmed in degrees or units, gSd is located in the Setup menu. Entering a value of (0) disables the Guaranteed Soak Deviation function.

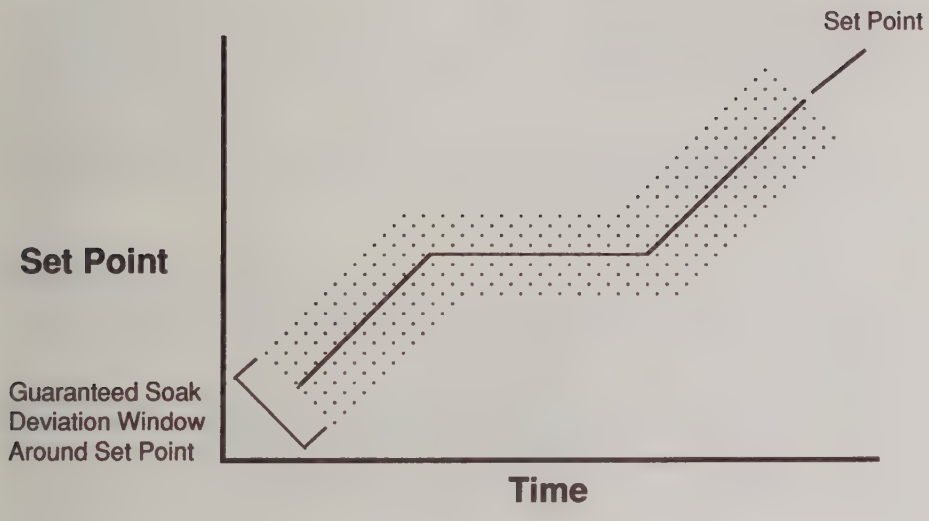


Figure 37 - Guaranteed Soak Deviation Example

Multiple Profiles

The Series 942 is a single profile control, but can be programmed for multiple profiles. To do this, enter your first profile; the next step you enter following the End step is the start of another profile. You can continue entering profiles until you run out of steps, remember there are a total of 24 steps.

Jumploop

The Series 942 can only jump backwards. A jump forces you to a step already performed. The Jump Step (JS) must be less than the current step. You cannot jumploop to the step that you are on.

Step 2	StPt		
Step 3	StPt		
Step 4	StPt		
Step 5	Jumploop	JS - 02	JC - 01
Step 6	End		

Your Jump Count (JC) can be anything from 0 - 100. If you enter 0, this will be an infinite loop and never progresses to Step 6.

This is a sample program. Depending on your application and parameter settings, your system may not respond like this.

Programming a Ramping Profile

Our first step in programming is to make a short ramp and soak profile. Step 1 initializes the set point to a known starting point for the ramp, Step 2 is a short ramp, and Step 3 is a soak step, which holds the programmed set point constant for the programmed time. Step 4 is an end step signalling the end of the profile.

1. When the lower display reads set point, press MODE once and you see the Prog parameter. Select YES in the upper display. Press the MODE key once again.

2. The Series 942 asks you for a StEP. The upper display reads (1).

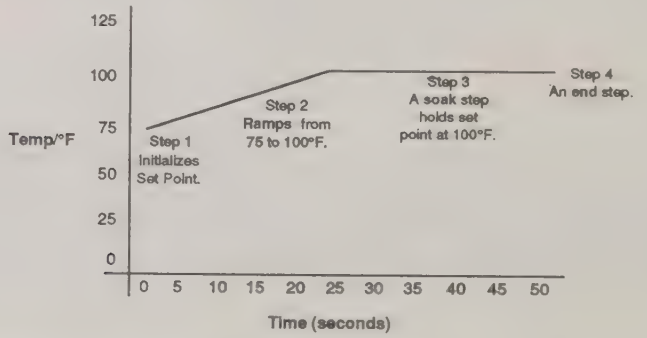
3. Press the MODE key and you are asked for a step type (StYP). The default is End. Use the UP/DOWN keys to select StPt (set point) then press MODE if it is not already there.

4. Use Table 4 to enter the corresponding parameters and values. The parameters appear from left to right on the table. Remember that the MODE key is used to progress through the menu, and the UP/DOWN keys are used to select parameters and values.

Table 4 - Series 942 Ramp and Soak Profile

StEP	StYP (Step Type)	SP (Set Point)	HOUr	Min	SEC	Ent1	Ent2	End	rtn
1	StPt	75	0	0	1	OFF	OFF	--	nO
2	StPt	100	0	0	25	On	OFF	--	nO
3	SoAh	--	0	0	25	On	OFF	--	nO
4	End							OFF	YES

NOTE:
If auxiliary outputs are not present or Ot3 and Ot4 are selected as alarms, the Ent1 and Ent2 parameters will not appear in the program menu.



Running Your Profile

1. Start your profile by pressing the HOLD/RUN key. You can be at any point except the Setup menu.

2. The RUN LED begins flashing. The upper display shows the step to begin on, and the bottom display shows the StEP parameter.

3. Press the HOLD/RUN key again. If not pressed within approximately 1 minute, the RUN procedure will abort. The profile starts running.

The RUN LED is continually lit. The upper display shows the PROCESS value, and the lower display shows the current set point.

You may step through the Run menu parameters with the MODE key to see what the step type is and what the parameters are set at. At any time you may press the HOLD/RUN key to stop the profile. To resume running the profile where it was stopped, press the HOLD/RUN key once; the RUN LED begins flashing. Now, press the MODE key to advance to the rESU parameter; once again, press the HOLD/RUN key. After the profile has ended the Run LED is off and the lower display reads OFF. This means the End step was selected as OFF, disabling all outputs.

Editing Your Profile

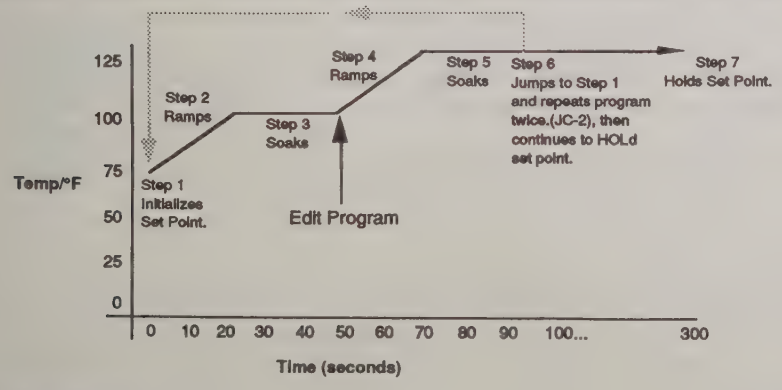
Now let's try editing the profile by expanding it with another ramp and soak step, adding a jumploop and programming the End step to hold. We'll jump to Step 1 and repeat Steps 1 through 6 two more times. This is accomplished by programming a Jump Step (JS) = 1 and Jump Count (JC) = 2. This means that once the 942 goes through the profile and reaches Step 6, it jumps back to Step 1 and repeats the profile two more times (Steps 1 - 5). It then continues to Step 7 and holds the set point and event status of the last step of the profile before the end step was encountered.

By this time you should understand the basic concept of the Series 942 and be able to get around on your own. Remember that the MODE key takes you through the menus and the UP/DOWN keys select parameters and values.

1. Return to the PROGRAM menu by selecting YES when Prog appears.
2. Press the MODE key and select (4) when StEP appears. We are going to change this step type from an End step to a Set Point step. This is our second ramp. Use Table 5 to enter values into the corresponding parameters.
3. Once you have edited your profile, run it again and watch its progress.

Table 5 - Editing Your Profile, Steps 4 - 7.

StEP	StYP (Step Type)	SP (Set Point)	HOUr	Min	SEC	Ent1	Ent2	JS	JC	End	rtn
4	StPt	125	0	0	25	OFF	On	--	--	--	nO
5	StPt	125	0	0	25	On	OFF	--	--	--	nO
6	JL	--	--	--	--	--	--	1	2	--	nO
7	End	--	--	--	--	--	--	--	--	HOLd	YES



NOTE:
If auxiliary outputs are not present or Ot3 and Ot4 are selected as alarms, the Ent1 and Ent2 parameters will not appear in the Program menu.

Chapter 6

How to Tune and Operate

Tuning - Automatic

Auto-tuning: The Series 942 can automatically tune the PID parameters to fit the characteristics of your particular thermal system.

The auto-tuning procedure operates on a thermal response value — slow, medium, or fast. Use the slow thermal response when your process does not need to reach set point too rapidly, or if it usually does not exceed set point. A fast thermal response produces a rapid temperature change over a short period of time.

Once the auto-tune sequence has begun, the heat proportional band is set to 0 and the control goes into an ON/OFF mode of control at 90% of the established set point. The displayed set point remains unchanged.

The cool output remains off for the duration of tuning. Once the control finishes "learning" the system, it returns to a standard PID control with the heat PID values automatically set as a result of auto-tuning. Tuning is complete within 80 minutes. Any change of set point, while in auto-tune, re-initiates the auto-tune procedure.

To start auto-tuning:

1. **Press the MODE key** until the **AUt** parameter appears in the data display. The AUt parameter will not appear under the Operation menu if the set point value is OFF.

2. **Select a thermal response value**, 1 = slow, 2 = medium, and 3 = fast, using the UP/DOWN keys. A thermal response value of 2 satisfactorily tunes most thermal systems.

3. **Press the MODE key.** While the control is in the tuning mode, the lower display alternately displays the normal information and the **AUt** parameter. The time between alternations is 1 second.

4. **When tuning is complete,** the displays return to their previous state and **AUt** reverts to 0. The 942 installed the appropriate PID tuning parameters and saved them in the non-volatile memory.

To abort auto-tuning, reset the **AUt** parameter to 0, or cycle power off and on. In all cases, aborting auto-tune restores all original values.

Tuning - Manual

For optimum control performance, tune the Series 942 to the thermal system. The tuning settings here are for a broad spectrum of applications; your system may have somewhat different requirements. **NOTE: This is a slow procedure, taking from minutes to hours to obtain optimum value.**

1. **Apply power to the Series 942** and enter a set point. Begin with these Operation Parameters: **Pb1** = 1, **rE1/It1** = 0.00, **Ct1** = 5, **rA1/dE1** = 0.00, **CAL** = 0, **AUt**= 0.

2. **Proportional Band Adjustment (Output 1)**: Gradually increase **Pb1** until the Upper display temperature stabilizes to a constant value. The process temperature will not be right on set point because the initial reset value is 0.00 repeats per minute. (When **Pb1** = 0; **rE1** and **rA1** are inoperative, and the 942 functions as a simple ON/OFF control.) The HYSX parameter determines the switching differential value.

3. **Reset/Integral Adjustment**: Gradually increase **rE1/It1** until the upper display temperature begins to oscillate or "hunt." Then slowly decrease **rE1/It1** until the Upper display stabilizes again near set point.

4. **Cycle Time Adjustment**: Set **Ct1** as required. Faster cycle times sometimes achieve the best system control. However, if a mechanical contactor or solenoid is switching power to the load, a longer cycle time may be desirable to minimize wear on the mechanical components. Experiment until the cycle time is consistent with the quality of control you want.

5. **Rate/Derivative Adjustment**: Increase **rA1/dE1** to 1.00 minute. Then raise set point by 20° to 30°F, or 11° to 17°C. Observe the system's approach to set point. If the load temperature overshoots set point, increase **rA1/dE1** to 2.00 minutes.

   Then raise set point by 20 to 30°F, or 11 to 17°C and watch the approach to the new set point. If you increase **rA1/dE1** too much, approach to the set point will be very sluggish. Repeat as necessary until the system rises to the new set point without overshooting or approaching the set point too slowly.

6. **Calibration Offset Adjustment:** You may want your system to control to a temperature other than the value coming from the input sensor, such as when the sensor cannot directly measure the process. If so, measure the difference between that temperature (perhaps at another point in the system) and the process value showing in the Upper display. Then enter the **CAL** offset value you want. Calibration offset adds or subtracts degrees from the value of the input signal.

NOTE:
The cycle time (Ct1) parameter will not appear if Output 1 (Ot1) is a process output.

NOTE:
An X applies to either Hysteresis 1 or 2.

Changing the Position of an Auxiliary Jumper

Whenever you change the position of a jumper, follow this procedure:

1. Remove power from the Series 942. Turn the front panel screw 90° counter-clockwise.
2. Grip the front panel bezel and pull it straight out from the control case. The control chassis will come out of the case as you pull the bezel.
3. Set the jumper to the position you want. See Figure 38 for jumper location.
4. Return the control chassis to the case. Be sure you have it oriented correctly. It will not fit in upside down, but check just the same. Press firmly, but gently, to seat the chassis.

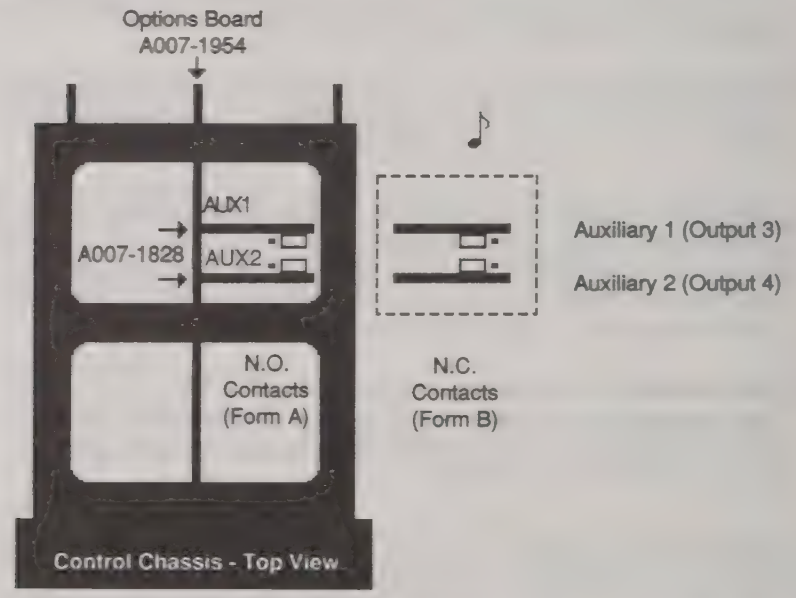


Figure 38 - Auxiliary Jumper Location.

♪ NOTE:
Depending on the unit you order, your control may have 0, 1, or 2 auxiliary jumpers.

The auxiliary output de-energizes upon an alarm or power interruption to the 942's power supply. When you select **N.O. Contacts**, the contact is open when an alarm occurs. When selecting **N.C. Contacts**, the contact closes when an alarm occurs. When an event is ON the N.O. contacts close and the N.C. contacts open. If the L3 or L4 LED on the front panel are lit, this indicates an energized event or alarm condition for Output 3 or 4.

Using Alarms

The Series 942 has two alarm types, Process or Deviation. A **Process alarm** sets an absolute temperature. When the process exceeds that absolute temperature limit an alarm occurs. The Process alarm set points may be independently set high and low.

A **Deviation alarm** alerts the operator when the process strays too far from set point. The operator can enter independent high and low alarm settings. The reference for the deviation alarm is the set point. Any change in set point causes a corresponding shift in the deviation alarm. **Example:** If the set point is 100°F, and a deviation alarm is set at +7°F as the high limit, and -5°F as the low limit, the high alarm trips at 107°F, and the low alarm at 95°F. If you change the set point to 130°F, the alarms follow the set point and trip at 137°F and 125°F.

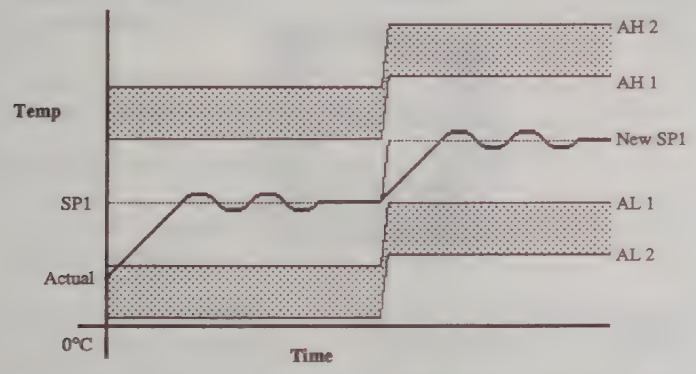


Figure 39 - Deviation Alarm Example

NOTE:
For Deviation alarms: When the End step in the Program menu is OFF or OFFA, the deviation alarms are active (relay energized).

For Process alarms: When the End step is OFF, process alarms are disabled in a de-energized position. When OFFA is selected, the process alarm works normally.

Both Process and Deviation alarms can be latching or non-latching. When the alarm condition is removed a **non-latching alarm automatically** clears the alarm output. The operator must **manually clear** a **latching alarm** before the alarm disappears. The alarm condition must also be removed before the alarm can be cleared.

Flashing 'LO" or "HI" in the lower display indicates an alarm. The Lower display alternately shows information from the current parameter and the "LO" or "HI" alarm message at one second intervals. The alarm output is de-energized and the L3 or L4 LED is lit.

To clear an alarm...

- **First correct the alarm condition, then...**
  - **If the alarm is latching...**
    Clear it manually; press the HOLD/RUN key once as soon as the process temperature is inside the alarm limit according to the HYSX parameter.
  - **If the alarm is non-latching...**
    The alarm will clear itself automatically as soon as the process temperature is inside the alarm limit according to the HYSX parameter.

NOTE:
An X applies to either Hysteresis 3, or 4.

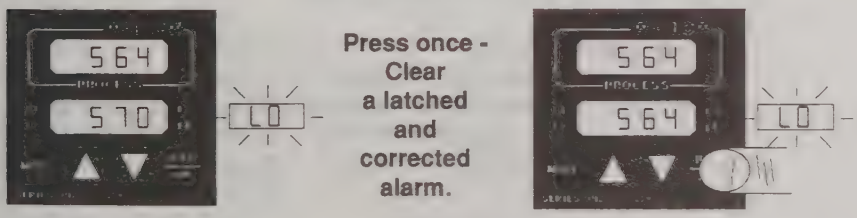


Figure 40 - Alarm Display Examples

Alarm Silencing for auxiliary output 3 is available with the deviation alarm. If it is a non-latching alarm, this overrides the normal alarm output functions only during initial power up. If latching, press the HOLD/RUN key once to override the alarm output function. With alarm silencing, the alarm message and alarm LED's show the alarm condition but the output remains in a non-alarm state until the process value is within the safe region of the deviation band. Any future deviation outside this safe band triggers an alarm.

WARNING:
An alarm display will be masked by an error condition or when the control is in the Calibration or Setup Menus.

Error Code Messages

Four dashes, "- - - -", in the upper display indicate a Series 942 error.

- The error code is visible in the lower display.

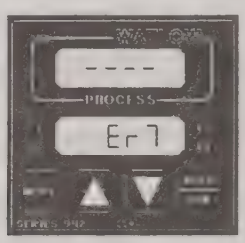


Figure 41 - Error Code Display Example

WARNING:
Electrical noise or a noise event, vibration or excess environmental moisture or temperature may cause Series 942 errors to occur. If the cause of an error is not otherwise apparent, check for these.

- **Error code definitions and actions...**

Er 1 - Sensor overrange error
The sensor input generated a value that was higher than that allowed for the range of the sensor, or the A/D circuitry malfunctioned. Enter a valid input. The A/D value is above the range limits, but within the A/D conversion limits. Make sure the **In** parameter matches your sensor.

Er 2 - Sensor underrange error
The sensor input generated a value that was lower than that allowed for the range of the sensor, or the A/D circuitry malfunctioned. Enter a valid input. The A/D value is below the range limits, but within the A/D conversion limits. Make sure the **In** parameter matches your sensor.

Er 3 - Ambient error
Check the specification for the ambient temperature range.

Er 4 - Configuration error
The unit's microprocessor is faulty; call the factory.

Er 5 - Non volatile checksum error
The nonvolatile memory checksum discovered a checksum error. Unless a momentary power interruption occurred while the unit was storing data, the nonvolatile memory is bad. Call the factory.

Er 6 - A/D underflow error
The A/D circuit is underrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and the sensor functions properly, call the factory. The A/D underrange voltage is too low to convert an A/D signal. Make sure the **In** parameter matches your sensor.

Er 7 - A/D overflow error
The A/D circuit is overrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and the sensor functions properly, call the factory. The A/D underrange voltage is too high to convert an A/D signal. Make sure the **In** parameter matches your sensor.

Error Code Actions

- **Error codes Er 1, Er 2, Er 3, Er 6, and Er 7 will result in these conditions:**
  - Control outputs turn OFF.
  - The auxiliary output (if present and programmed as an alarm) will be in the alarm state (LED lit). If programmed as an event, the output turns OFF.
  - The Upper display will read "- - - -".
  - The Lower display indicates the error code.
  - The HOLD/RUN and MODE keys are inactive. The UP/DOWN keys may be used together to enter the Setup Menu.
- **To clear a corrected error...**
  - Cycle power to the control, or MODE through the SETUP menu until you return to the set point.
  - If an error occurs while in the RUN mode, the program cannot be resumed. Set point defaults to the previous value.

- **Error codes Er 4 and Er 5 will result in these conditions:**
  - Control outputs turn OFF.
  - The auxiliary outputs, if present, are in their alarm state (de-energized with the LED lit).
  - The Upper display indicates "- - - -".
  - The Lower display indicates the error code.
  - All Keys are inactive.
  - All Setup Menu parameters return to default values.
  - The above conditions will occur regardless of the value of LOC, or the presence of the Setup or Calibration Menus.
- **To clear a corrected error...**
  - Cycle power to the control.

Specifications Appendix 1

Control Mode

- 24 step ramping control or programmer.
- Simple, non-ramping set point.
- Single input, dual outputs.
- Optional dual auxiliary outputs, selectable as alarms or time based events.
- Optional retransmit of set point or process variable.
- RS-422A, RS-423A, or EIA-485 data communications available.
- Control outputs: User selectable as: Heat, Heat/Cool, Cool, Cool/Heat
  - Outputs independent, related via dead band for Heat/Cool.
  - ON/OFF: Selectable per Outputs 1 and 2.
  - Proportional band: 0 to 999°F/0 to 555°C/0 to 999 Units or % of span
    Reset: 0.00 to 9.99 repeats per minute.
    Integral: 0 and 00.1 to 99.9 minutes per repeat.
    Rate/Derivative: 0.00 to 9.99 minutes.
    Cycle time: 1 to 60 seconds.
  - Dead band: ± 99°F, ± 55°C or ± 99 Units
    (± 9.9°F, ± 5.5°C or ±9.9 units for rtd.1 and process units)

NOTE:
An X applies to either Hysteresis 1, 2, 3, or 4.

Operator Interface

- Membrane front panel.
- Dual, four digit 0.56" (14 mm) LED displays.
- MODE, HOLD/RUN, UP, and DOWN keys.

Input

- Thermocouple, RTD, and electrical process input.
- Automatic cold junction compensation for thermocouple.
- RTD input 2 or 3 wire, platinum, 100 ohm @ 0°C, software selectable:
  JIS curve #3916 (0.003916 Ω/Ω/°C) or DIN curve #3850 (0.003850 Ω/Ω/°C).
- Sensor break protection de-energizes control outputs to protect system.
- Grounded or ungrounded sensors.
- °F, °C, or process variable units are user selectable.
- J t/c: 32 to 1382°F or 0 to 750°C
  K t/c: -328 to 2282°F or -200 to 1250°C
  T t/c: -328 to 662°F or -200 to 350°C
  N t/c: 32 to 2282°F or 0 to 1250°C
  C t/c: 797 to 4200°F or 425 to 2315 °C
  PT 2 (Platinel 2) 32 to 2543°F or 0 to 1395°C
  R t/c: 32 to 2642°F or 0 to 1450°C
  S t/c: 32 to 2642°F or 0 to 1450°C
  *B t/c: *32 to 3092°F or 0 to 1700°C
  1° RTD: -328 to 1112°F or -200 to 600°C
  0.1° RTD: -99.9 to 392.0°F or -99.9 to 200.0°C
  0-5VDC: -500 to 3500 Units
  4-20mA: -500 to 3500 Units

NOTE:
*** B t/c: Useable range is suggested to be 1598 to 3092°F or 870 to 1700°C. Range is at 32° to allow using at low temperatures without range low sensor errors.**

Primary Output (Heating or Cooling)

- Solid state relay, Form A 0.5A @ 24VAC min., 264VAC maximum, opto-isolated, zero cross switching. Off state impedance is 20KΩ minimum for 942A-X**B**XX-X0000 units, and infinite impedance for 942A-X**K**XX-X000 units.
- Electromechanical relay, Form C, 6A @ 120/240VAC, 6A @ 28VDC, 1/8 hp. @ 120VAC, 125VA @ 120VAC. Off state impedance is 20KΩ min.
- Switched DC Open collector, 500Ω minimum load resistance, 1KΩ load, 9mA minimum, 22mA maximum, non-isolated.
- 0-20mA or 4-20mA reverse or direct into a 600Ω maximum load impedance, non-isolated.
- 0-10VDC or 0-5VDC reverse or direct into a 1KΩ minimum load impedance, non-isolated.

Secondary Output (Heat, Cool or None)

- Solid state relay, Form A 0.5A @ 24VAC min., 264VAC maximum, opto-isolated, zero cross switching. Off state impedance is 20KΩ minimum for 942A-XBXX-X0000 units, and infinite impedance for 942A-XKXX-X000 units.
- Electromechanical relay, Form A, 6A @ 120/240VAC, 6A @ 28VDC, 1/8 hp. @ 120VAC, 125VA @ 120VAC. Off state impedance is 20KΩ min.
- Switched DC, Open collector, 500Ω minimum load resistance, 1KΩ load, 9mA minimum, 22mA maximum, non-isolated.

Auxiliary Outputs

- Electromechanical relay, Form A (N.O.) or B (N.C.), 6A @ 28VDC, 1/8 hp. @ 120VAC, 125VA @ 120VAC. Off state impedance is 20KΩ minimum.
- Latching or non-latching.
- Process or deviation.
- Separate high and low values.
- Alarm silencing (inhibit) on power up for Alarm 1.

Retransmit Output

- 4-20mA into a 600Ω maximum load, non-isolated. Retransmit of process or set point. User selectable range.
- 0-5VDC into a 10KΩ minimum load, non-isolated. Retransmit of process or set point. User selectable range.

Accuracy

- Calibration Accuracy and Sensor Conformity: ± 0.1% of span, ± 1 LSD, 77°F ± 5°F (25°C ± 3°C) ambient & rated line voltage ± 10%.
- Accuracy Span: 1000°F or 540°C minimum.
- Temperature Stability: 0.1°F/°F (0.1°C/°C) change in ambient.
- Voltage Stability: ± 0.01% of span / % of rated line voltage.

Communications

- Serial data communications.
- RS-422A or RS-423A (RS-232C compatible) or EIA-485, user selectable.
- ANSI X3.28 protocol, or XON/XOFF protocol.
- Isolated.
- Data logging.
- #6 compression type screw terminals.

Agency Approvals

- UL and CSA pending.

Terminals

- #6 compression type screw terminals.

Power

- 120/240VAC +10%, -15%, 50/60Hz, ± 5%.
- 16VA maximum.
- Data retention upon power failure via nonvolatile memory.

Operating Environment

- 32 to 149°F/0 to 65°C.
- 0 to 90% RH, non-condensing.

Dimensions

• Height:	3.8 in	97 mm
• Width:	3.8 in	97 mm
• Overall depth:	7.0 in	178 mm
• Behind panel depth:	6.0 in	153 mm
• Weight:	2.5 lb max.	0.4 kg

Series 942 Model Number Information

The Series 942 Model Number, listed on your unit sticker, is defined below.

9 4 2 A – _ _ _ _ – 0 0 0

Control Series

942 = 1/4 DIN, single input, dual output, dual auxiliary outputs, dual digital displays.

Inputs Type

1 = Type J, K, T, N, C, PT 2 thermocouple
2 = Type J, K, T, N, C, PT 2 thermocouple, RTD 1°, 4 - 20mA, 0-5VDC
3 = Type J, K, T, N, C, PT 2 thermocouple, RTD 0.1°, 4 - 20mA, 0-5VDC
4 = Type R, S, B thermocouple

#1 Output Type

B = Solid State Relay, Form A, 0.5A
C = Switched DC, Open Collector, non-isolated
D = Mechanical Relay, Form C, 6A
E = Process 0 - 10VDC, non-isolated
F = Process 4 - 20mA, non-isolated
G = Process 0 - 20mA, non-isolated
H = Process 0 - 5VDC, non-isolated
K = Solid State Relay without contact suppression Form A, 0.5A

#2 Output Type

A = None
B = Solid State Relay, Form A, 0.5A
C = Switched DC, Open Collector, non-isolated
D = Mechanical Relay, Form C, 6A
K = Solid State Relay without contact suppression Form A, 0.5A

Auxiliary Outputs

0 = None
1 = Single, Mechanical Relay, 6A, Form A or B
2 = Dual, Mechanical Relay, 6A, Form A or B
3 = Single, Mechanical Relay, 6A/0 - 5VDC retransmit
4 = Single, Mechanical Relay, 6A/4 - 20mA retransmit
5 = No auxiliary output/0 - 5VDC retransmit
6 = No auxiliary output/4 - 20mA retransmit

Communications

A = None
B = Isolated RS-423/RS-422
D = Isolated EIA-485

Appendix 2

Noise and Installation Guidelines

Installation Guidelines For Preventing Noise

For improved electrical noise immunity, install the Series 942 as far away as possible from motors, relays, and other similar electrical noise generators.

Do not run low power (sensor input) lines in the same bundle as AC power lines. Grouping these lines in the same bundle can create electrical noise interference which may result in error codes in the Series 942.

The Culprit

Most noise problems stem from wiring practices. They're the major means of coupling noise from its sources to the control circuit. The following information will tell you how to eliminate or decrease noise.

An Information Resource

For wiring guidelines , refer to the IEEE Standard No. 518-1982, available from IEEE, Inc. 345 East 47th Street, New York, NY 10017.

Noise Sources

- Switches and relay contacts operating inductive loads such as motors, coils, solenoids, and relays, etc.
- Thyristors or other semiconductor devices which are not zero crossover-fired (randomly-fired or phase angle-fired devices).
- All welding machinery.
- Heavy current carrying conductors.
- Fluorescent and neon lights.

How To Decrease Noise Sensitivity

- Physical separation and wire routing must be given careful consideration in planning the layout of the system. For example, A.C. power supply lines should be bundled together and physically kept separate from input signal lines (sensor lines). A 12" (305 mm) minimum separation is usually effective. Keep all switched output signal lines (high power level) separate from input signal lines (sensor lines). Cross other wiring at 90° angles whenever crossing lines is unavoidable.

- Another important practice is to look at the system layout; identify and locate electrical noise sources such as solenoids, relay contacts, motors, etc. Route the wire bundles and cables as far away as possible from these noise sources. Don't mount relays or switching devices close to a microprocessor control. Don't have phase angle-fired devices in the same electrical enclosure or on the same power line with the control.
- Shielded cables should be used for all low power signal lines to protect from magnetic and electrostatic coupling of noise. Some simple pointers are:

  ◊ Whenever possible, run low level signal lines unbroken from signal source to the control circuit.
  ◊ Connect the shield to the control circuit common at the control end only. Never leave the shield unconnected at both ends. Never connect both shield ends to a common or ground.
  ◊ Maintain shield continuity at daisy chain connection points by reconnecting the broken shield.
  ◊ Assume no electrostatic shielding when using the shield as a signal return. If you must, use triaxed cable (electrostatically shielded coaxial cable).

- Twisted pair wire should be used any time control circuit signals must travel over two feet, or when they are bundled in parallel with other wires.

- The size or gauge of wire should be selected by calculating the maximum circuit current and choosing the gauge meeting that requirement. Using greatly larger wire sizes than required generally will increase the likelihood of electrostatic (capacitance) coupling of noise.

- Ground loops must be eliminated in the entire control system. There are obvious loops which can be spotted by studying the "as-built" wiring diagram. There are also the not-so-obvious ground loops that result from connecting internal circuit commons in the manufacturer's equipment. An example is a control circuit designed to work with a grounded sensor input.

- Do not daisy chain A.C. power (or return) lines, or output signal (or return) lines to multiple control circuits. Use a direct line from the power source to each input requiring A.C. power. Avoid paralleling L1 (power lead) and L2 (return lead) to load power solenoids, contactors, and control circuits. If an application uses L1 (power lead)to switch a load, L2 (return lead) has the same switched signal and could couple unwanted noise into a control circuit.

- Grounding the chassis of each piece of equipment in the system is very important. Here is a simple practice that works best. 1) Connect each individual equipment to the over-all chassis immediately adjacent to that piece. 2) Tie all major chassis ground terminals together with one lead (usually green wire) tied to ground at one point. Don't connect ground to the control case if the control is in a grounded enclosure (preventing ground loops).

- Do not confuse chassis grounds (safety ground) with control circuit commons or with A.C. supply L2 (return or neutral line). Each return system wiring must be separate. Absolutely never use chassis ground (safety) as a conductor to return circuit current.

How To Eliminate Noise

- Use "snubbers" ("QUENCHARC™") to filter out noise generated by devices such as relays, relay contacts, solenoids, motors, etc. A snubber is a simple filter device using a 0.1µf, 600 volt, non-polarized capacitor in series with a 100 ohm, 1/2 watt resistor. The device can be used on A.C. or D.C. circuits to effectively dampen noise at its source.

- The general purpose Watlow snubber, described above, is 0804-0147-0000. For other "QUENCHARC" sizes contact:

  PAKTRON
  P.O. Box 5439
  Lynchburg, VA 24502
  Phone: 804/239-6941

- A Metal Oxide Varistor (MOV) can be used to limit voltage "spikes" that occur on the A.C. supply lines as a result of lightning strikes, switching large motors, etc. The MOV is available in several varieties and for 115 or 230 volt lines. The device dissipates the voltage "spikes" to ground and in doing so repeatedly, deteriorates its ability to function. MOVs have a limited life. Watlow stocks several MOVs. See Table 7.

- "Islatrols" and other similar power line filters are designed to carry the power for the control circuit and "buffer" the control circuit from A.C. line noise. Devices like the Islatrol use media (electromagnetic filtering) other than electric circuits to filter out electrical noise. Take care in matching the power capabilities of the filter with power demands of the circuit. Keep line filters as close to the control as possible to minimize the area for interference pick up.

- Islatrols are available from: Control Concepts Corporation
  328 Water Street
  P.O. Box 1380
  Binghamton, NY 13902-1380
  Phone: 607/724-2484

  I - 101 (1A, 120VAC)
  I - 105 (5A, 120VAC)
  I - 115 (15A, 120VAC)
  I - 202 (2.5A, 208/240VAC)
  I - 207 (7.5A, 208/240VAC)

- The ultimate protection is an "uninterruptable" power supply. This "senses" the A.C. power line; when the line fluctuates, a battery powered 60Hz inverted circuit takes over, supplying power within one-half to one cycle of the A.C. line; very expensive.

How to Check for Ground Loops

To check for ground loops, disconnect the ground wire at the ground termination. Measure the resistance from the wire to the point where it was connected. The ohmmeter should read a high ohm value. If you have a low ohm value across this gap, there is at least one ground loop present in your system.

Or check for continuity; your reading should be "open." If you do find continuity, you must now begin looking for the ground loops. Begin disconnecting ground in the system one at a time, checking for continuity after each disconnection. When continuity reads "open" you have eliminated the ground loop(s). Also, as you reconnect grounds, keep making the continuity test. It is possible to reconnect a ground loop.

Noise Suppression Devices Available From Watlow

Watlow Controls stocks a few key noise suppression parts. You may order these by calling your local Watlow distributor.

Table 6 - Noise Suppression Device Ratings

Item	Electrical Ratings	Part Number
Common Mode Line Filter	250V, 3 Amp	0804-0196-0000
Differential Mode Line Filter	Refer to the Islatrol listing above.	
Metal Oxide Varistor	150V, 80 Joule	0802-0273-0000
MOV130V, 38 Joule	0802-0304-0000	
MOV275V, 75 Joule	0802-0266-0000	
MOV275V, 140 Joule	0802-0405-0000	

Line Filtering Configurations For Controls

These three diagrams show you filter configurations for removing input power noise. Choose the one best suited for your system. For very dirty or critical applications - use a microcomputer-regulated power supply or Uninterruptable Power Supply (U.P.S.). Don't fasten common mode line filters or filters with metal cases to metal that is at ground potential. This prevents ground loops and maintain filter effectiveness.

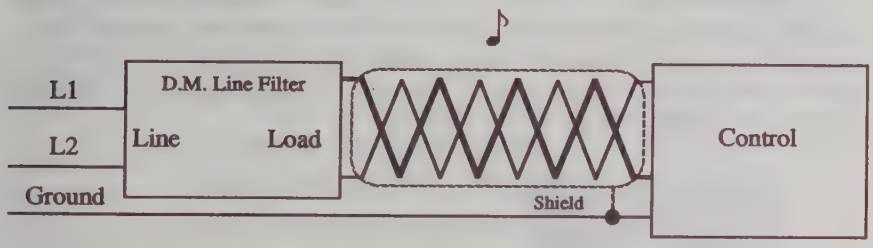


Figure 42 - Differential Mode Filter Wiring

NOTE:
Keep filters 12" (305 mm) or less from the control. Minimize the line distance where noise can be reintroduced to the control.

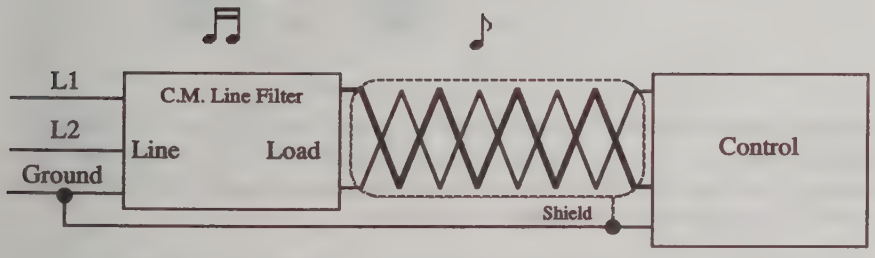


Figure 43 - Common Mode Filter Wiring

NOTE:
To prevent ground loops do not fasten common mode line filters or filters with metal that is at ground potential. Doing so will reduce filter effectiveness.

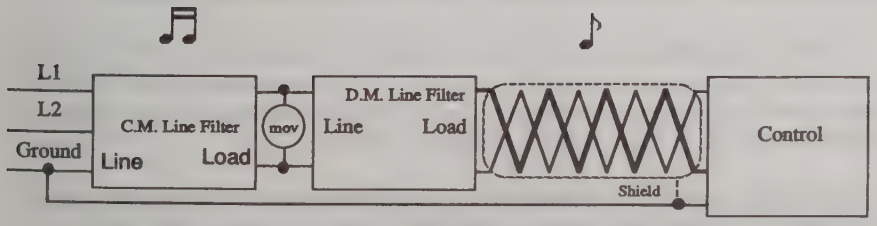


Figure 44 - Combination Differential/Common Mode Filter Wiring

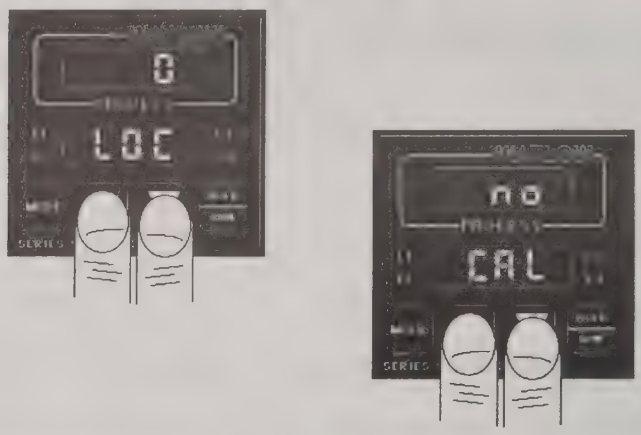
Appendix 3

Before attempting to calibrate, make sure you have the proper equipment called for in each procedure.

Entering the Calibration Menu

In the Calibration Menu, various input signals must be supplied in order for the control to go through its auto calibration. The calibration menu can only be entered from the LOC parameter in the Setup menu. Press the UP/DOWN keys simultaneously for 3 seconds (± 1 second). The CAL parameter appears in the lower display with "no" in the upper display.

Figure 45 - Entering the Calibration Menu.



NOTE:
Calibration values are not retained unless you are in the RUN mode. Do not enter the RUN mode until you are at the correct input parameters.

Any inadvertent change in the displayed data, when pressing the UP/DOWN keys, is ignored. Calibration values are not retained unless you are in the RUN mode. Press the UP/DOWN keys to change the upper display to "YES." Press the MODE key to enter the calibration sequence.

NOTE:
While in the Calibration Menu, all outputs are OFF, except the process output.

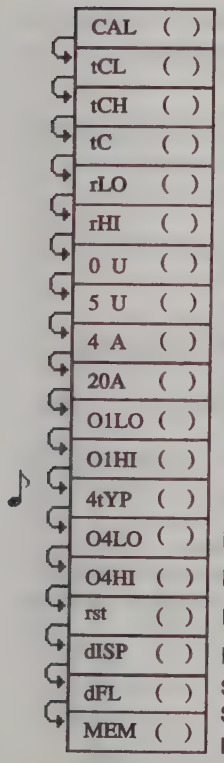
Upon entering the calibration menu, the top display window indicates CAL. The upper display continues to indicate CAL (with the exception of calibration of the process outputs) while the operator walks through the entire calibration parameter list. While calibrating a process output, the upper display contains a numeric value to be slewed up or down until the output value is correct. The control uses the lower display to prompt the user as to what the input should be **The rSt parameter restores the factory calibration values to the Series 942.** If you calibrate your control incorrectly, you have the option to default to the original values. Once you leave the CAL menu, the values are entered.

WARNING:
Improper calibration will affect the accuracy of your control. A factory restore (rst) feature is provided at the end of the Calibration menu.

The dFL parameter allows you to select either U.S. parameters which include displaying the proportional band in degrees or units, rate, reset, and °F. Or you can select SI (System International); those parameters displayed are proportional band in % of span, integral, derivative, and °C.

Once the information has been properly established and maintained for 5 to 10 seconds, the MODE key can be used to display the next parameter. After the final input is established, press the MODE key to return the unit to the configuration menu at the top of the parameter list.

Calibration Menu



YES to calibrate, No skips to display test.

Input 0.00mV for low thermocouple input.

Input 50.00mV (or 16.035 for r, S or b units) for high thermocouple input.

Connect a "J" T/C compensator, with inputs shorted. T/C units only.

Connect the JIS RTD low resistance per model number.

Connect the JIS RTD high resistance per model number.

Set the voltage source to 0.000 volts.

Set the voltage source to 5.000 volts.

Set the current source to 4.00mA.

Set the current source to 20.00mA.

Press the UP/DOWN keys until Output 1 reads process low.

Press the UP/DOWN keys until Output 1 reads process high.

Factory select for Output 4 type.

Press the UP/DOWN keys until Output 4 reads process low.

Press the UP/DOWN keys until Output 4 reads process high.

Restores factory calibration values.

Factory use only.

Select US (prop. band in ° or units, rate, reset, °F) or SI (prop. band in % of span, integral, derivative, °C).

Factory use only.

Figure 46 - Calibration Menu

NOTE:

The Output 4 rELY parameter is for alarms or events, and the PrOC parameter is for retransmit output.

Thermocouple Field Calibration Procedure

Before attempting to calibrate, make sure you have the proper equipment called for in each procedure.

Equipment Required

- Type "J" or "R" reference compensator with reference junction at 32°F/0°C, or
  Type "J" or "R" thermocouple calibrator set at 32°F/0°C.
- Precision millivolt source, 0 - 50mV minimum range, 0.01mV resolution

♪ **NOTE:**

Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

Setup And Calibration ♪

1. Connect the AC line voltage L1, L2, and ground to the proper terminals on the 942. See Chapter 2.
2. Connect the millivolt source to Terminal #9 Negative and Terminal #7 Positive on the Series 942 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54.

♫ **NOTE:**

Not all parameters will appear. They are dependent on your unit type. Use only the steps that apply to your unit.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the thermocouple calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.
5. At the **tCL** parameter, enter 0.00mV from the millivolt source to the control. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the "**CH** parameter, enter 50.00mV for type "J" units or 16.035mV for type "R" units from the millivolt source to the Series 942. Allow at least 10 seconds to stabilize. Press the MODE key.
7. At the **tC** parameter, disconnect the millivolt source, and connect the reference compensator or T/C calibrator to Terminal #9 Negative, and Terminal #7 Positive on the Series 942 terminal strip. Allow 10 seconds for the control to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the thermocouple calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

RTD Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- 1KΩ precision decade resistance box with 0.01 ohms resolution.

Setup And Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 942. See Chapter 2.

2. Connect the decade resistance box to Terminal #4, 5 and 6 on the terminal strip. Use regular 20 - 24 gauge wire of the same length and type.

3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until the **rLO** parameter is displayed.

NOTE:
Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the RTD calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.

5. At the **rLO** parameter, set the decade resistance box to the correct low setting. See the table below. This parameter can be calibrated to JIS or DIN. Allow at least 10 seconds to stabilize. Press the MODE key.

NOTE:
Not all parameters will appear. They are dependent on your unit type. Use only the steps that apply to your unit.

	Calibration	Low	High
942A-2XX0-0000	1°	17.31	317.33
942A-3XX0-0000	0.1°	59.59	177.13

Table 7 - RTD Settings.

6. At the **rHI** parameter, set the decade resistance box to the correct high setting. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the RTD calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

0 - 5 Volt Input Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- Precision voltage source 0-5 volt minimum range with 0.001 volt resolution.

Setup And Calibration

NOTE:
Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

1. Connect the AC line voltage L1, L2, and ground to the proper terminals on the 942. See Chapter 2.
2. Connect the voltage/current source to Terminal #1 and #3 on the Series 942 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until the **OU** parameter is displayed.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the 0 - 5 Volt input calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

NOTE:
Not all parameters will appear. They are dependent on your unit type. Use only the steps that apply to your unit.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.
5. At the **0U** parameter, set the voltage/current source to 0.000volts. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the **5U** parameter, set the voltage/current source to 5.000 volts. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the 0 - 5 Volt input calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

4-20mA Input Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- Precision current source 0-20mA minimum range with 0.01 mA resolution.

Setup And Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals on the Series 942. Jumper for correct line voltage. See Chapter 2.

2. Connect the voltage/current source to Terminal #1 and #3. Jumper Terminal #2 to #3 on the Series 942 terminal strip. Use regular 20 - 24 gauge wire.

3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until the **4A** parameter is displayed.

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the 4 - 20mA input calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

NOTE:

Not all parameters will appear. They are dependent on your unit type. Use only the steps that apply to your unit.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.

5. At the **4A** parameter, set the mA source to 4.00mA. Allow at least 10 seconds to stabilize. Press the MODE key.

6. At the **20A** parameter, set the voltage/current source to 20.00mA. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the 4-20mA input calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

0-5 or 0-10 Volt Output Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- 20KΩ, 1/4 watt, 10% resistor
- 4 1/2 digit Digital Multimeter.

Setup and Calibration

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 942. See Chapter 2.

2. Connect the multimeter across the 20KΩ resistor to Terminal #17 (+) and #18 (-)for 0-5Volt units on the Series 942 terminal strip. Use Terminal #17 (+) and #16 (-) for 0-10Volt units. Use regular 20 - 24 gauge wire.

3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until the **O1LO** parameter is displayed.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the 0 - 5 Volt output calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.

5. At the **O1LO** parameter, the multimeter should read approximately 0.000V. Allow at least 10 seconds to stabilize.

6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for -0.2V ±0.1V on 0-5Volt units and 0.0V ± 0.1V for 0-10Volt units. Press the MODE key.

7. At the **O1HI** parameter, the multimeter should read approximately 5.000V. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations.

8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 5.2V ± 0.1V for 0-5Volt units and 5.0V ± 0.1V for 0-10Volt units.

9. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the output calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

0-20/4-20mA Output Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- 470Ω, 1/2 watt 10% resistor.
- 4 1/2 digit Digital Multimeter.

Setup and Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 942. See Chapter 2.

2. Connect the multimeter in series with the 470Ω resistor to Terminal #17 (+) and #18 (-) for 4-20mA units, on the Series 942 terminal strip. Use Terminal # 17 (+) and #16 (-) for 0-20mA units. Use regular 20 - 24 gauge wire.

3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until **O1LO** parameter is displayed.

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the 4-20mA output calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.

5. At the **O1LO** parameter, the multimeter should read approximately 0mA for 0-20mA units and 4mA for 4-20mA units. Allow at least 10 seconds to stabilize.

6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 0.0mA ± 0.10mA on 0-20mA units, and 3.85mA ± 0.10mA on 4-20mA units. Press the MODE key.

7. At the **O1HI** parameter, the multimeter should read approximately 20mA. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations.

8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 20.0mA ± 0.10mA on 0-20mA units and 20.15mA ±0.10mA on 4-20mA units.

9. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the output calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice. Press the HOLD/RUN key twice to exit the RUN mode.

0 - 5 Volt Retransmit Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- 20KΩ, 1/4 watt, 10% resistor.
- 4 1/2 digit Digital Multimeter.

Setup and Calibration

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 942. See Chapter 2.

2. Connect the multimeter across the 20KΩ resistor to Terminal #25 Positive and #24 Negative on the Series 942 terminal strip. Use regular 20 - 24 gauge wire.

3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until the O4LO parameter is displayed.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the 0 - 5 Volt retransmit calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.

5. At the **O4LO** parameter, the multimeter should read approximately 0V. Allow at least 10 seconds to stabilize.

6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 0.0 volts. Press the MODE key.

7. At the **O4HI** parameter, the multimeter should read approximately 5V. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations.

8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 5.0 volts. Press the MODE key.

9. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the 0 - 5 volt retransmit calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

4-20mA Retransmit Field Calibration Procedure

Before attempting any calibration procedure, make sure you have the proper equipment called for in each procedure.

Equipment Required

- 470Ω, 1/2 watt 10% resistor.
- 4 1/2 digit Digital Multimeter.

Setup and Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 942. See Chapter 2.

2. Connect the multimeter in series with the 470Ω resistor to Terminal #25 Positive and #24 Negative on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.

3. Apply power to the unit and allow it to warm up for 15 minutes. After **warm-up** put the unit in the CAL menu. See Page 54. Press the MODE key until the **O4LO** parameter is displayed.

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See the Setup and Operation Tables, and the Master Step Chart, Pages 27, 30 and 35.

IMPORTANT:

When the RUN LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment. When you have completed all of the 4 - 20mA retransmit calibration parameters, press the HOLD/RUN key twice. Failure to do so will result in inaccurate calibration values.

4. Press the HOLD/RUN key twice to enter the RUN mode. The unit is calibrating when the RUN LED is ON. Make sure the unit is in the RUN mode **only** when you are in the correct parameters. See Page 55.

5. At the **O4LO** parameter, the multimeter should read approximately 4mA. Allow at least 10 seconds to stabilize.

6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 4.00mA. Press the MODE key.

7. At the **O4HI** parameter, the multimeter should read approximately 20mA. Allow at least 10 seconds to stabilize. The unit will leave the CAL mode if 1 minute passes between key activations.

8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 20.00mA.

9. Press the HOLD/RUN key twice to exit the RUN mode. To conclude the 4 - 20mA retransmit calibration, advance the MODE key to the next parameter or exit the Calibration menu by pressing the HOLD/RUN key twice.

Glossary, A-J

Alarm: A condition, generated by a controller, indicating that the process has exceeded or fallen below the set or limit point.

Alarm Silence: Disables the alarm relay output.

Anti-reset: Control feature that inhibits automatic reset action outside the proportional band.

Automatic prompts: Data entry points where a microprocessor-based control "prompts" or asks the operator/programmer for information input.

Auto-tune: Automatically tunes the Series 942 PID parameters to fit the characteristics of your particular thermal system.

Auxiliary Output: Output 3 and 4 can be programmed as an alarm or event if your control was ordered with this option.

Bumpless transfer: When transferring from auto to manual operation, the control output(s) will not change ("bumpless," smooth transition).

Closed loop: Control system that has a sensing device for process variable feedback.

Cold junction: Point of connection between thermocouple metals and the electronic instrument.

Cold junction compensation: Electronic means to compensate for the effective temperature at the cold junction.

Cycle time: The time necessary to complete a full ON-through-OFF period in a time proportioning control system.

Data Logging: A convenient replacement for chart recorders. Information is sent from the 942 to a serial printer. Provides a handy reference to review process performance.

Dead band: A temperature band between heating and cooling functions.

Derivative: Anticipatory action that senses the rate of change of the process, and compensates to minimize overshoot and undershoot. Also "rate."

Deviation: The difference between the value of the controlled variable and the value at which it is being controlled.

Deviation alarm: An alarm referenced at a fixed number of degrees, plus or minus, from set point.

Default parameters: The parameters, or programmed instructions, permanently stored in microprocessor software to provide a data base.

DIN: Deutsche Industrial Norms, a widely-recognized German standard for engineering units.

Display capability: In a digital indicating instrument, the entire possible span of a particular parameter or value.

Droop: Difference in temperature between set point and stabilized process temperature.

Duty cycle: Percentage of "load ON time" relative to total cycle time.

Event: An ON/OFF auxiliary output relay signal. You can use events based on time or other process variables to trigger peripheral equipment or process.

Form A: Single Pole Single Throw. Utilizes the N.O. and Common contacts. These contacts will close when the relay coil is energized. The contacts will open when power is removed from the control.

Form B: Single Pole Single Throw.Utilizes the N.C. and Common contacts. These contacts will open when the relay coil is energized. The contacts will close when power is removed from the control.

Form C: Single Pole Double Throw. Utilizes the N.O., N.C. and Common contacts. The user has the option of wiring for a Form A or Form B contact. Refer to Form A and Form B above for more information.

Hysteresis: In ON/OFF control, the temperature change necessary to change the output from full ON to full OFF.

Hunting: Oscillation or fluctuation of process temperature between set point and process variable.

Input: Process variable information being supplied to the instrument.

Integral: Control action that automatically eliminates offset, or "droop," between set point and actual process temperature. Also "reset."

Isolation: Electrical separation of sensor from high voltage circuitry. Allows for application of grounded or ungrounded sensing element.

JIS: Japanese Industrial Standards. Also Japanese Industrial Standards Committee (JISC). Establishes standards on equipment and components.

Offset: Adjustment to actual input temperature and to the temperature values the Series 942 uses for display and control.

ON/OFF control: Control of temperature about set point by turning the output full ON below set point and full OFF above set point in the heat mode.

Open loop: System with no sensory feedback.
Output: Action in response to difference between set point and process variable.

Overshoot: Condition where temperature exceeds setpoint due to initial power up or process changes.

P control: Proportioning control.

Parameter: A physical property whose value determines the response of an electronic control to given inputs.

PD control: Proportioning control with rate action.

PI control: Proportioning control with auto-reset.

PID control: Proportioning control with auto-reset and rate.

Process variable: Thermal system element to be regulated, such as time, temperature, relative humidity, etc.

Profile: A sequence of instructions (program) you enter into the Series 942.

Programmed display data: Displayed information which gives the operator/programmer the "programmed" or intended process information, i.e., intended set point, intended alarm limit, etc. See "Actual displayed data."

Proportional band: Span of temperature about the set point where time proportional control action takes place.

Proportioning control: See Time Proportioning Control.

Rate: Anticipatory action that senses the rate of change of temperature and compensates to minimize overshoot. Also "derivative."

Rate Band: A thermal control band defining where the rate (derivative) function begins. A Watlow rate band occurs centered on set point at one or more times the width of the proportional band.

Reset: Control action that automatically eliminates offset, or "droop," between set point and actual process temperature. Also "integral."

Retransmit Output: An auxiliary function of Output 4

RTD: Resistance Temperature Detector. Resistive sensing device displaying resistance versus temperature characteristics. Displays positive temperature coefficient.

Set point: Intended value of the process variable.

Slave: A device (chart recorder, temperature control) operating on command from the Series 942.

Switching sensitivity: In ON/OFF control, the temperature change necessary to change the output from full ON to full OFF.

Thermal system: A regulated environment consisting of a heat source, heat transfer medium, sensing device and a process variable control instrument.

Thermocouple: Temperature sensing device that is constructed of two dissimilar metals wherein a measurable, predictable voltage is generated corresponding to temperature.

Thermocouple break protection: Fail-safe operation that assures output shutdown upon an open thermocouple condition.

Three mode control: Proportioning control with reset and rate.

Time Proportioning Control: Action which varies the amount of ON and OFF time when "close" to the set point, i.e., in the proportional band. This variance is proportional to the difference between the set point and the actual process temperature. In other words, the amount of time the output relay is energized depends on the system temperature.

Triac: Solid state switching device.

Upper display data: Displayed information which gives the operator/programmer real or "actual" data, i.e., actual process temperature. See "Programmed display data."

Warm Start: Start-up condition where all program information is remembered by the instrument's memory back-up protection.

Zero switching: Action that provides output switching only at the zero voltage crossing points of the AC line.

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Warranty

The Watlow Series 942 is warranted to be free of defects in material and workmanship for 36 months after delivery to the first purchaser for use, providing that the unit has not been misapplied.

Since Watlow has no control over their use, and sometimes misuse, we cannot guarantee against failure. Watlow's obligations hereunder, at Watlow's option, are limited to replacement, repair or refund of purchase price, and parts which upon examination prove to be defective within the warranty period specified. This warranty does not apply to damage resulting from transportation, alteration, misuse or abuse.

Watlow Controls

Watlow Controls is a division of Watlow Electric Manufacturing Company of St. Louis, Missouri. Watlow is an established manufacturer of industrial electric heating products, in business since 1922. Watlow boasts the ability to begin with a full set of specifications and to complete an industrial product that is manufactured totally in-house, in the U.S.A. Products designed and manufactured by Watlow are electric heating elements, sensors, electronic temperature controls and power switching devices.

The Watlow Controls operation has been designing solid state electronic devices since 1962, and has earned the reputation as an excellent supplier to original equipment manufacturers. These OEMs depend upon Watlow Controls to provide compatibly engineered controls which they can incorporate into their products with confidence.

Watlow Controls resides in a 100,000 square foot marketing, engineering and manufacturing facility in Winona, Minnesota.

Returns

1. Call Watlow Customer Serivice, 507/454-5300, for a Return Material Authorization (RMA) number before returning any item for repair. We need this information:
   - Ship to address
   - Bill to address
   - Contact name
   - Phone number
   - Ship via
   - Your P.O. number
   - Symptoms and/or special instructions
   - Name and phone number of person returning the material.

2. Prior approval and an RMA number, from the Customer Serivice Department, is needed when returning any unused product for credit. Make sure the RMA number is on the outside of the carton, and on all paperwork returned. Ship on a Freight Prepaid basis.

3. After we receive your return, we will examine it and determine the cause for your action.

4. In cases of manufacturing defect, we will enter a repair order, replacement order, or issue credit for material. A 20 percent restocking charge is applied for all returned stock controls and accessories.

5. If the unit is unrepairable, it will be returned to you with a letter of explanation. Repair costs will not exceed 50 percent of the original cost.

Shipping Claims

When you receive your Watlow control, examine the package for any signs of external damage it may have sustained enroute. If there is apparent damage either outside the box or to its contents, make a claim with the shipper immediately. Save the original shipping carton and packing material.

Watlow Controls, 1241 Bundy Blvd., Winona, MN 55987, 507/454-5300, Fax: 507/452-4507

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